# MCP9844

## ±1°C Accurate, 1.8V Digital Temperature Sensor

### Features

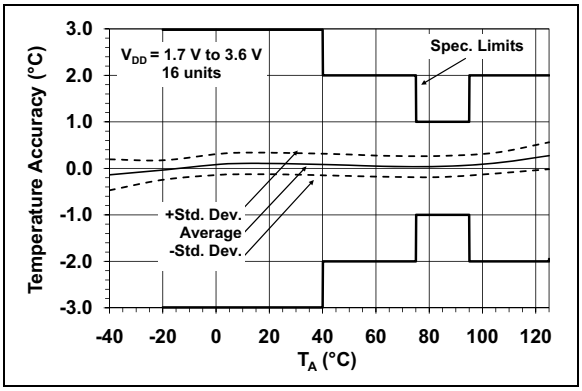
- 1MHz, 2-wire I²C™ Interface
- User Selectable Measurement Resolution:
  - +0.5°C, +0.25°C, +0.125°C, +0.0625°C
- User Programmable Temperature Limits:
  - Temperature Window Limit
  - Critical Temperature Limit
- User Programmable Temperature Alert Output
- Specified $V_{DD}$ Range: 1.7V to 3.6V
- Operating Current: 100 µA (typical)
- Available Package: 8-Pin TDFN

### Temperature Sensor Features

- Temperature-to-Digital Converter (°C)
- Sensor Accuracy (Grade B):
  - ±0.2°C/±1°C (typ./max.) → +75°C to +95°C
  - ±0.5°C/±2°C (typ./max.) → +40°C to +125°C
  - ±1°C/±3°C (typ./max.) → -40°C to +125°C

### Typical Applications

- Temperature sensing for Solid State Drive (SSD)
- General Purpose Temperature Datalog
- General Purpose
- Industrial Applications
- Industrial Freezers and Refrigerators
- Food Processing
- Personal Computers and Servers
- PC Peripherals
- Consumer Electronics
- Handheld/Portable Devices




### Description

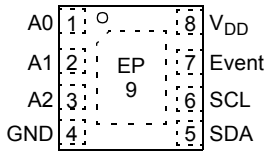
Microchip Technology Inc.'s MCP9844 digital temperature sensor converts temperature from -40°C to +125°C to a digital word. It provides an accuracy of ±0.2°C/±1°C (typical/maximum) from +75°C to +95°C with an operating voltage of 1.7V to 3.6V.

The MCP9844 digital temperature sensor comes with user programmable registers that provide flexibility for temperature sensing applications. The registers allow user selectable settings such as Shutdown or Low-Power modes, and the specification of temperature event boundaries. When the temperature changes beyond the specified event boundary limits, the MCP9844 outputs an Alert signal at the Event pin. The user has the option of setting the temperature event output signal polarity as either an active-low or active-high comparator output for the thermostat operation, or as a temperature event interrupt output for microprocessor-based systems.

This sensor has an industry standard I²C Fast Mode Plus compatible 1 MHz serial interface.

### Package Types

**8-Pin 2x3 TDFN ***




* Includes Exposed Thermal Pad (EP); see Table 3-1.

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## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

$V_{DD}$..... 4.0V
Voltage at all Input/Output pins ..... GND – 0.3V to 4.0V
Pin A0..... GND – 0.3V to 11V
Storage temperature .....-65°C to +150°C
Ambient temp. with power applied .....-40°C to +125°C
Junction Temperature ($T_J$).....+150°C
ESD protection on all pins (HBM:MM) ..... (4 kV:200V)
Latch-Up Current at each pin (25°C)..... ±200 mA

**†Notice:** Stresses above those listed under "Maximum ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

## TEMPERATURE SENSOR DC CHARACTERISTICS

**Electrical Specifications:** Unless otherwise indicated, $V_{DD}$ = 1.7V to 3.6V, GND = Ground, and $T_A$ = -40°C to +125°C.

| Parameters | Sym | Min | Typ | Max | Unit | Conditions |
|---|---|---|---|---|---|---|
| **Temperature Sensor Accuracy** | | | | | | |
| +75°C < $T_A \leq$ +95°C | $T_{ACY}$ | -1.0 | ±0.2 | +1.0 | °C | $V_{DD}$ = 1.8V |
| +40°C < $T_A \leq$ +125°C | | -2.0 | ±0.5 | +2.0 | °C | |
| -40°C < $T_A \leq$ +125°C | | -3.0 | ±1 | +3.0 | °C | |
| **Temperature Conversion Time** | | | | | | |
| 0.5°C/bit | $t_{CONV}$ | — | 30 | — | ms | |
| 0.25°C/bit | | — | 65 | 125 | ms | 15 s/sec (typical) (See **Section 5.2.4**) |
| 0.125°C/bit | | — | 130 | — | ms | |
| 0.0625°C/bit | | — | 260 | — | ms | |
| **Power Supply** | | | | | | |
| Specified Voltage Range | $V_{DD}$ | 1.7 | — | 3.6 | V | |
| Operating Current | $I_{DD_TS}$ | — | 100 | 500 | µA | |
| Shutdown Current | $I_{SHDN}$ | — | 0.2 | 1 | µA | $T_A$ = 85°C |
| Power On Reset (POR) | $V_{POR_TS}$ | — | 1.5 | — | V | Threshold for falling $V_{DD}$ voltage |
| Settling time after POR | $t_{POR}$ | — | — | 1 | ms | For warm and cold power cycles |
| Power Supply Rejection, | ∆°C | — | 0.2 | — | °C | $V_{DD}$ = 1.7V to 3.6V |
| $V_{DD}$ = 1.7V, 2.5V, 3.3V | | — | ±1 | — | °C | $V_{DD_AC}$ = $V_{DD}$ +150 $mV_{PP\ AC}$ (0 to 1 MHz) and $T_A$ = +25°C, |
| **Event Output (Open-Drain output, external pull-up resistor required), see Section 5.2.3** | | | | | | |
| High-level Current (leakage) | $I_{OH}$ | — | — | 1 | µA | $V_{OH}$ = $V_{DD}$ |
| Low-level Voltage | $V_{OL}$ | — | — | 0.4 | V | $I_{OL}$= 3 mA (Active-Low, Pull-up Resistor) |
| **Thermal Response, from +25°C (Air) to +125°C (oil bath)** | | | | | | |
| TDFN-8 | $t_{RES}$ | — | 0.7 | — | s | Time to 63% (89°C) |


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## INPUT/OUTPUT PIN DC CHARACTERISTICS

**Electrical Specifications:** Unless otherwise indicated, $V_{DD}$ = 1.7V to 3.6V, GND = Ground and $T_A$ = -40°C to +125°C.

| Parameters | Sym | Min | Typ | Max | Units | Conditions |
|---|---|---|---|---|---|---|
| Serial Input/Output (SCL, SDA, A0, A1, A2) | | | | | | |
| **Input** | | | | | | |
| High-level Voltage | $V_{IH}$ | $0.7V_{DD}$ | — | — | V | |
| Low-level Voltage | $V_{IL}$ | — | — | $0.3V_{DD}$ | V | |
| Input Current | $I_{IN}$ | — | — | ±5 | µA | SDA and SCL only |
| Input Impedance (A0, A1, A2) | $Z_{IN}$ | — | 1 | — | MΩ | $V_{IN} > V_{IH}$ |
| Input Impedance (A0, A1, A2) | $Z_{IN}$ | — | 200 | — | kΩ | $V_{IN} < V_{IL}$ |
| **Output (SDA only)** | | | | | | |
| Low-level Voltage | $V_{OL}$ | — | — | 0.4 | V | $I_{OL}$= 3 mA |
| High-level Current (leakage) | $I_{OH}$ | — | — | 1 | µA | $V_{OH} = V_{DD}$ |
| Low-level Current | $I_{OL}$ | 3 | — | 20 | mA | $V_{OL}$ = 0.4V, $V_{DD} \geq$ 2.2V |
| | | 6 | — | — | mA | $V_{OL}$ = 0.6V |
| Capacitance | $C_{IN}$ | — | 5 | — | pF | |
| SDA and SCL Inputs | | | | | | |
| Hysteresis | $V_{HYST}$ | — | $0.05V_{DD}$ | — | V | |
| Spike Suppression | $T_{SP}$ | — | — | 50 | ns | |

## TEMPERATURE CHARACTERISTICS

**Electrical Specifications:** Unless otherwise indicated, $V_{DD}$ = 1.7V to 3.6V, GND = Ground, and $T_A$ = -40°C to +125°C.

| Parameters | Sym | Min | Typ | Max | Units | Conditions |
|---|---|---|---|---|---|---|
| **Temperature Ranges** | | | | | | |
| Specified Temperature Range | $T_A$ | -40 | — | +125 | °C | **Note 1** |
| Operating Temperature Range | $T_A$ | -40 | — | +125 | °C | |
| Storage Temperature Range | $T_A$ | -65 | — | +150 | °C | |
| **Thermal Package Resistances** | | | | | | |
| Thermal Resistance, 8L-TDFN | $\theta_{JA}$ | — | 52.5 | — | °C/W | |

**Note 1:** Operation in this range must not cause $T_J$ to exceed Maximum Junction Temperature (+150°C).

## SERIAL INTERFACE TIMING SPECIFICATIONS

**Electrical Specifications:** Unless otherwise indicated, GND = Ground, $T_A$ = -40°C to +125°C, and $C_L$ = 80 pF **Note 1**.

| | | $V_{DD}$= 1.7V to 3.6V | | $V_{DD}$= 2.2V to 3.6V | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 100 kHz | | 400 kHz | | 1000 kHz | | |
| **Parameters** | **Sym** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** | **Units** |
| **2-Wire I²C™ Interface** | | | | | | | | |
| Serial port frequency (**Note 2**, **4**) | $f_{SCL}$ | 10 | 100 | 10 | 400 | 10 | 1000 | kHz |
| Low Clock (**Note 2**) | $t_{LOW}$ | 4700 | — | 1300 | — | 500 | — | ns |
| High Clock | $t_{HIGH}$ | 4000 | — | 600 | — | 260 | — | ns |
| Rise time (**Note 5**) | $t_R$ | — | 1000 | 20 | 300 | — | 120 | ns |
| Fall time (**Note 5**) | $t_F$ | 20 | 300 | 20 | 300 | — | 120 | ns |
| Data in Setup time (**Note 3**) | $t_{SU:DAT}$ | 250 | — | 100 | — | 50 | — | ns |
| Data in Hold time (**Note 6**) | $t_{HD:DI}$ | 0 | — | 0 | — | 0 | — | ns |
| Data out Hold time (**Note 4**) | $t_{HD:DO}$ | 200 | 900 | 200 | 900 | 0 | 350 | ns |
| Start Condition Setup time | $t_{SU:STA}$ | 4700 | — | 600 | — | 260 | — | ns |
| Start Condition Hold time | $t_{HD:STA}$ | 4000 | — | 600 | — | 260 | — | ns |
| Stop Condition Setup time | $t_{SU:STO}$ | 4000 | — | 600 | — | 260 | — | ns |
| Bus Idle/Free | $t_{B-FREE}$ | 4700 | — | 1300 | — | 500 | — | ns |
| Time out | $t_{OUT}$ | 25 | 35 | 25 | 35 | 25 | 35 | ms |
| Bus Capacitive load | $C_b$ | — | — | — | 400 | — | 100 | pf |

**Note 1:** All values referred to $V_{IL\ MAX}$ and $V_{IH\ MIN}$ levels.

**2:** If $t_{LOW} > t_{OUT}$, the temperature sensor I²C™ interface will time out. A Repeat Start command is required for communication.

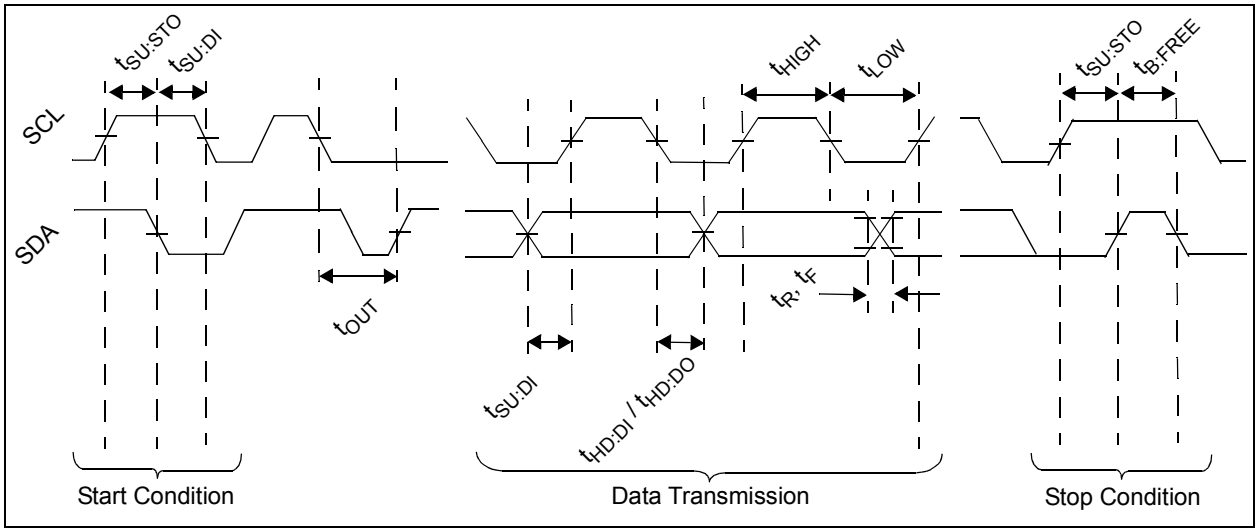
**3:** This device can be used in a Standard mode I²C-bus system, but the requirement $t_{SU:DAT} \geq 250$ ns must be met. This device does not stretch SCL Low period. It outputs the next data bit to the SDA line within $t_{R\ MAX} + t_{SU:DAT\ MIN}$ = 1000 ns + 250 ns = 1250 ns (according to the Standard-mode I²C-bus specification) before the SCL line is released.

**4:** As a transmitter, the device provides internal minimum delay time $t_{HD:DAT\ MIN}$ to bridge the undefined region (min. 200 ns) of the falling edge of SCL $t_{F\ MAX}$ to avoid unintended generation of Start or Stop conditions.

**5:** Characterized but not production tested.

**6:** As a receiver, SDA should not be sampled at the falling edge of SCL. SDA can transition $t_{HD:DI}$ 0 ns after SCL toggles Low.

## TIMING DIAGRAM





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## 2.0 TYPICAL PERFORMANCE CURVES

**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

**Note:** Unless otherwise indicated, $V_{DD}$ = 1.7V to 3.6V, GND = Ground, SDA/SCL pulled-up to $V_{DD}$, and $T_A$ = -40°C to +125°C.

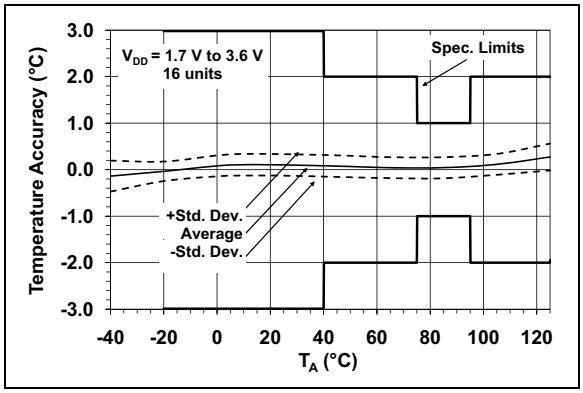


***FIGURE 2-1:*** *Temperature Accuracy.*

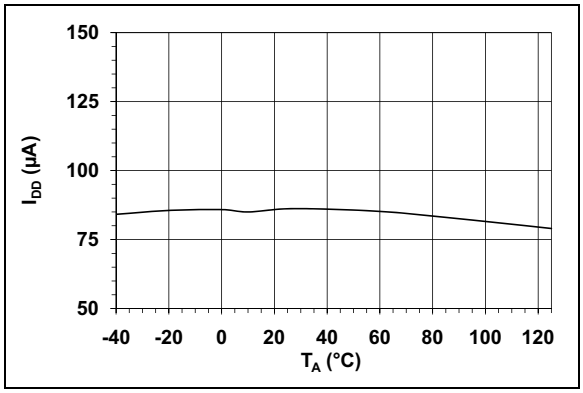


***FIGURE 2-4:*** *Supply Current Vs. Temperature.*

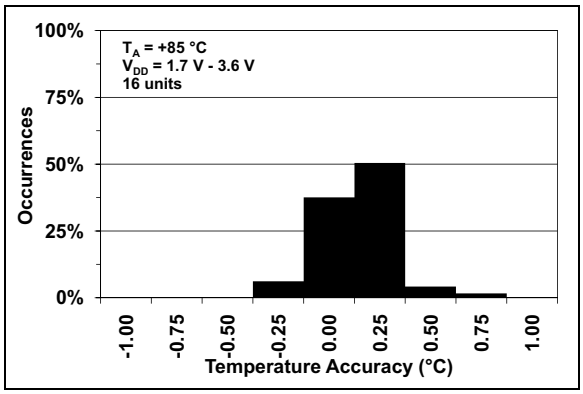


***FIGURE 2-2:*** *Temperature Accuracy Histogram, $T_A$ = + 85 °C.*

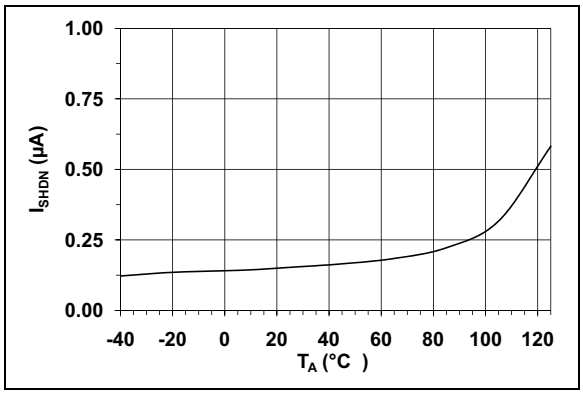


***FIGURE 2-5:*** *Shutdown Current Vs. Temperature.*

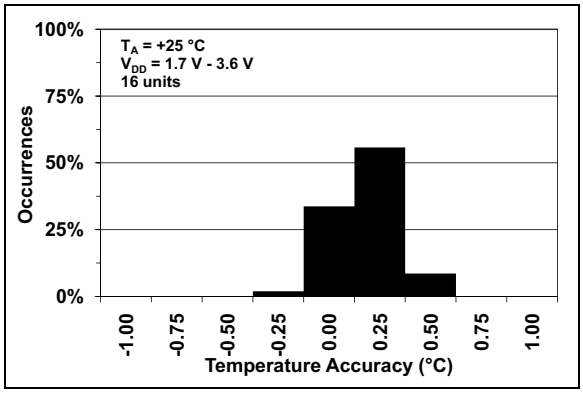


***FIGURE 2-3:*** *Temperature Accuracy Histogram, $T_A$ = + 25 °C.*

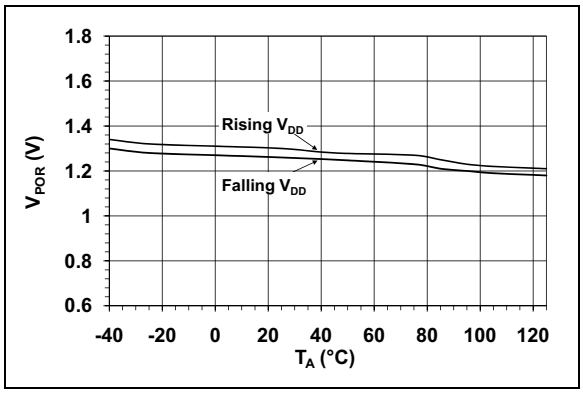


***FIGURE 2-6:*** *Power-on Reset Threshold Voltage Vs. Temperature.*

**Note:** Unless otherwise indicated, $V_{DD}$ = 1.7V to 3.6V, GND = Ground, SDA/SCL pulled-up to $V_{DD}$, and $T_A$ = -40°C to +125°C.

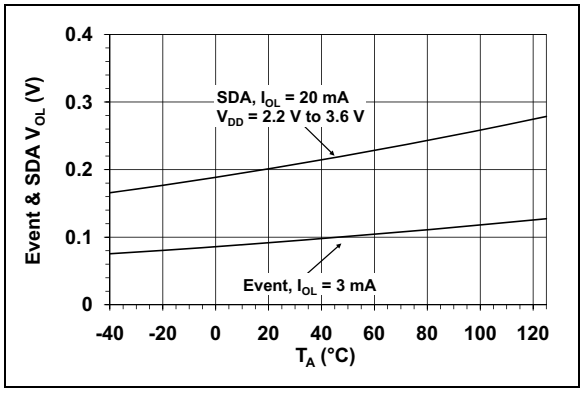


***FIGURE 2-7:*** *Event Output and SDA $V_{OL}$ Vs. Temperature.*

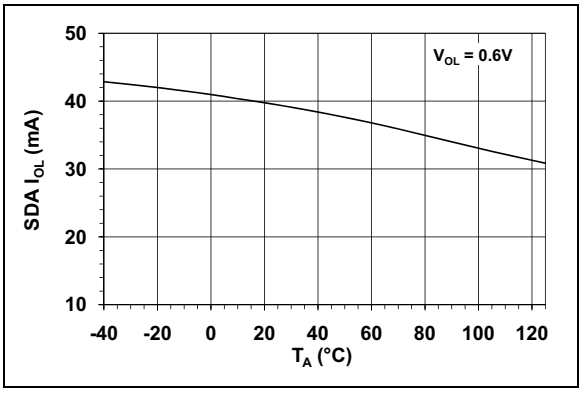


***FIGURE 2-10:*** *SDA $I_{OL}$ Vs. Temperature.*

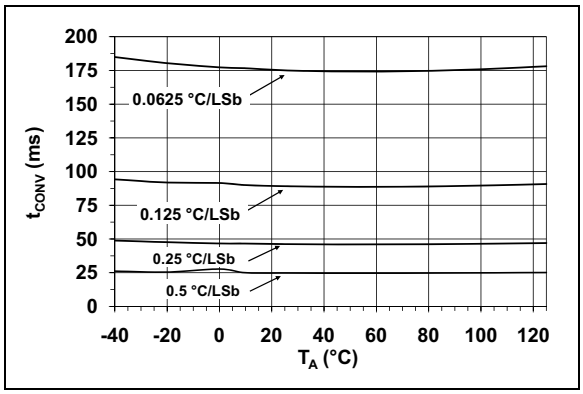


***FIGURE 2-8:*** *Temperature Conversion Rate Vs. Temperature.*

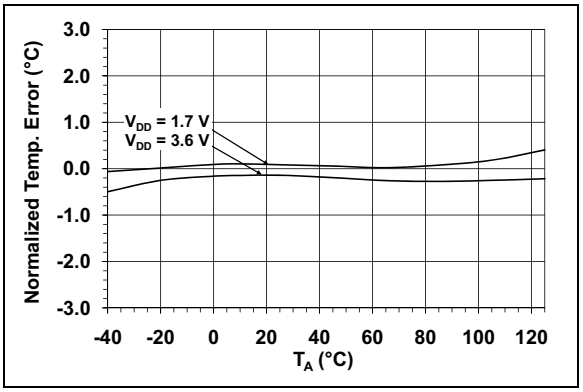


***FIGURE 2-11:*** *Line Regulation: Change in Temperature Accuracy Vs. Change in $V_{DD}$.*

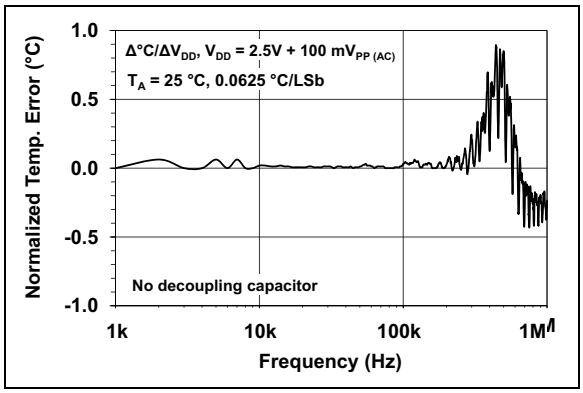


***FIGURE 2-9:*** *Power Supply Noise Rejection: Normalized Temperature Vs. Power Supply Frequency.*

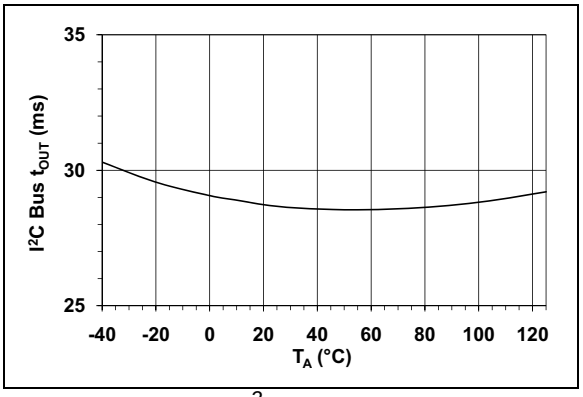


***FIGURE 2-12:*** *$I^2C$™ Protocol Time-out Vs. Temperature.*


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## 3.0 PIN DESCRIPTION

The descriptions of the pins are listed in Table 3-1.

**TABLE 3-1: PIN FUNCTION TABLES**

| MCP9844 TDFN | Symbol | Description |
|---|---|---|
| 1 | A0 | Slave Address |
| 2 | A1 | Slave Address |
| 3 | A2 | Slave Address |
| 4 | GND | Ground |
| 5 | SDA | Serial Data Line |
| 6 | SCL | Serial Clock Line |
| 7 | Event | Temperature Alert Output |
| 8 | $V_{DD}$ | Power Pin |
| 9 | EP | Exposed Thermal Pad (EP); can be connected to GND. |

### 3.1 Address Pins (A0, A1, A2)

These pins are device address input pins.

The address pins correspond to the Least Significant bits (LSb) of the address bits. The Most Significant bits (MSb) are A6, A5, A4, A3. Refer to Table 3-2.

**TABLE 3-2: MCP9844 ADDRESS BYTE**

| Device | Address Code | | | | Slave Address | | |
|---|---|---|---|---|---|---|---|
| | A6 | A5 | A4 | A3 | A2 | A1 | A0 |
| Sensor | 0 | 0 | 1 | 1 | X[1] | X[1] | X[1] |

**Note 1:** User selectable address is shown by X, where X is '1' or '0' for $V_{DD}$ and GND, respectively

All address pins have an internal pull-down resistor.

### 3.2 Ground Pin (GND)

The GND pin is the system ground pin.

### 3.3 Serial Data Line (SDA)

The SDA is a bidirectional input/output pin used to serially transmit data to/from the host controller. This pin requires a pull-up resistor. (See **Section 4.0 "Serial Communication"**.)

### 3.4 Serial Clock Line (SCL)

The SCL is a clock input pin. All communication and timing is relative to the signal on this pin. The clock is generated by the host or master controller on the bus. (See **Section 4.0 "Serial Communication"**.)

### 3.5 Temperature Alert, Open-Drain Output (Event)

The MCP9844 temperature Event output pin is an open-drain output. The device outputs a signal when the ambient temperature goes beyond the user programmed temperature limit. (See **Section 5.2.3 "Event Output Configuration"**.)

### 3.6 Power Pin ($V_{DD}$)

$V_{DD}$ is the power pin. The operating voltage range, as specified in the DC electrical specification table, is applied on this pin.

### 3.7 Exposed Thermal Pad (EP)

There is an internal electrical connection between the Exposed Thermal Pad (EP) and the GND pin; they can be connected to the same potential on the Printed Circuit Board (PCB). This provides better thermal conduction from the PCB to the die.

**NOTES:**


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# 4.0 SERIAL COMMUNICATION

## 4.1 2-Wire Standard Mode I²C™ Protocol-Compatible Interface

The MCP9844 serial clock input (SCL) and the bidirectional serial data line (SDA) form a 2-wire bidirectional Standard mode I²C compatible communication port (refer to the **Input/Output Pin DC Characteristics** table and the **Serial Interface Timing Specifications** table).

The following MCP9844 bus protocol is defined in Table 4-1.

**TABLE 4-1: MCP9844 SERIAL BUS PROTOCOL DESCRIPTIONS**

| Term | Description |
|---|---|
| Master | The device that controls the serial bus, typically a microcontroller. |
| Slave | The device addressed by the master, such as the MCP9844. |
| Transmitter | Device sending data to the bus. |
| Receiver | Device receiving data from the bus. |
| START | A unique signal from the master to initiate serial interface with a slave. |
| STOP | A unique signal from the master to terminate serial interface from a slave. |
| Read/Write | A read or write to the MCP9844 registers. |
| ACK | A receiver Acknowledges (ACK) the reception of each byte by polling the bus. |
| NAK | A receiver Not-Acknowledges (NAK) or releases the bus to show End-of-Data (EOD). |
| Busy | Communication is not possible because the bus is in use. |
| Not Busy | The bus is in the Idle state, both SDA and SCL remain high. |
| Data Valid | SDA must remain stable before SCL becomes high in order for a data bit to be considered valid. During normal data transfers, SDA only changes state while SCL is low. |

### 4.1.1 DATA TRANSFER

Data transfers are initiated by a Start condition (START), followed by a 7-bit device address and a read/write bit. An Acknowledge (ACK) from the slave confirms the reception of each byte. Each access must be terminated by a Stop condition (STOP).

Repeated communication is initiated after $t_{B\text{-}FREE}$.

This device does not support sequential register read/write. Each register needs to be addressed using the Register Pointer.

This device supports the Receive Protocol. The register can be specified using the pointer for the initial read. Each repeated read or receive begins with a Start condition and address byte. The MCP9844 retain the previously selected register. Therefore, they output data from the previously specified register (repeated pointer specification is not necessary).

### 4.1.2 MASTER/SLAVE

The bus is controlled by a master device (typically a microcontroller) that controls the bus access and generates the Start and Stop conditions. The MCP9844 is a slave device and does not control other devices in the bus. Both master and slave devices can operate as either transmitter or receiver. However, the master device determines which mode is activated.

### 4.1.3 START/STOP CONDITION

A high-to-low transition of the SDA line (while SCL is high) is the Start condition. All data transfers must be preceded by a Start condition from the master. A low-to-high transition of the SDA line (while SCL is high) signifies a Stop condition.

If a Start or Stop condition is introduced during data transmission, the MCP9844 releases the bus. All data transfers are ended by a Stop condition from the master.

### 4.1.4 ADDRESS BYTE

Following the Start condition, the host must transmit an 8-bit address byte to the MCP9844. The address for the MCP9844 temperature sensor is '0011,A2,A1,A0' in binary, where the A2, A1 and A0 bits are set externally by connecting the corresponding pins to $V_{DD}$ '1' or GND '0'. The 7-bit address transmitted in the serial bit stream must match the selected address for the MCP9844 to respond with an ACK. Bit 8 in the address byte is a read/write bit. Setting this bit to '1' commands a read operation, while '0' commands a write operation (see Figure 4-1).

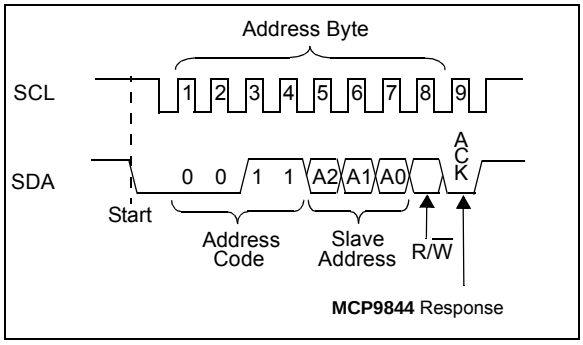


***FIGURE 4-1:*** *Device Addressing.*

### 4.1.5 DATA VALID

After the Start condition, each bit of data in the transmission needs to be settled for a time specified by $t_{SU-DATA}$ before SCL toggles from low-to-high (see **Serial Interface Timing Specifications** table).

### 4.1.6 ACKNOWLEDGE (ACK/NAK)

Each receiving device, when addressed, is obliged to generate an ACK bit after the reception of each byte. The master device must generate an extra clock pulse for ACK to be recognized.

The acknowledging device pulls down the SDA line for $t_{SU-DATA}$ before the low-to-high transition of SCL from the master. SDA also needs to remain pulled down for $t_{H-DATA}$ after a high-to-low transition of SCL.

During read, the master must signal an End-of-Data (EOD) to the slave by not generating an ACK bit (NAK) once the last bit has been clocked out of the slave. In this case, the slave will leave the data line released to enable the master to generate the Stop condition.

### 4.1.7 TIME OUT ($T_{OUT}$)

If the SCL stays low or high for time specified by $t_{OUT}$, the MCP9844 resets the serial interface. This dictates the minimum clock speed as specified in the specification.


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## 5.0 FUNCTIONAL DESCRIPTION

The MCP9844 temperature sensors consist of a band-gap type temperature sensor, a Delta-Sigma Analog-to-Digital Converter (ΣΔ ADC), user programmable registers and a 2-wire I²C protocol compatible serial interface. Figure 5-1 shows a block diagram of the register structure.

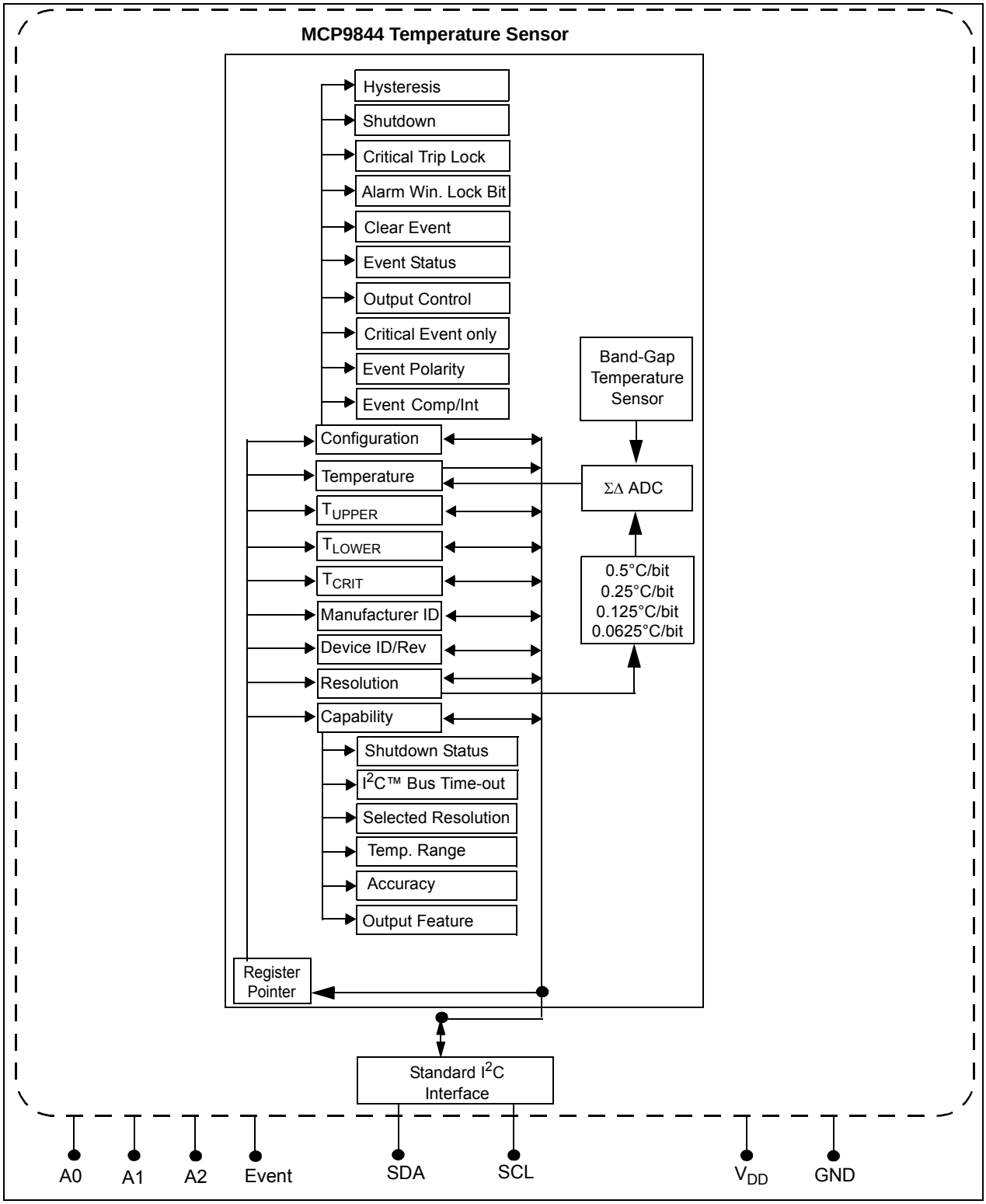


***FIGURE 5-1:*** *Functional Block Diagram.*

## 5.1 Registers

The MCP9844 device has several registers that are user accessible. These registers include the Capability register, Configuration register, Event Temperature Upper-Boundary and Lower-Boundary Trip registers, Critical Temperature Trip register, Temperature register, Manufacturer Identification register and Device Identification register.

The Temperature register is read-only and is used to access the ambient temperature data. The data is loaded in parallel to this register after $t_{CONV}$. The Event Temperature Upper-Boundary and Lower-Boundary Trip registers are read/writes. If the ambient temperature drifts beyond the user-specified limits, the MCP9844 device outputs a signal using the Event pin (refer to **Section 5.2.3 "Event Output Configuration"**). In addition, the Critical Temperature Trip register is used to provide an additional critical temperature limit.

The Capability register is used to provide bits describing the MCP9844's capability in measurement resolution, measurement range and device accuracy. The device Configuration register provides access to configure the MCP9844's various features. These registers are described in further detail in the following sections.

The registers are accessed by sending a Register Pointer to the MCP9844 using the serial interface. This is an 8-bit write-only pointer. However, the four Least Significant bits are used as pointers and all unused bits (bits 7-4) need to be cleared or set to '0'. Register 5-1 describes the pointer or the address of each register.

**REGISTER 5-1: REGISTER POINTER (WRITE ONLY)**

| W-0 | W-0 | W-0 | W-0 | W-0 | W-0 | W-0 | W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | Pointer Bits | | | |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | | | |
|---|---|---|---|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 7-4 **Writable Bits:** Write '0'

bit 3-0 **Pointer Bits:**

0000 = Capability register
0001 = Configuration register (CONFIG)
0010 = Event Temperature Upper-Boundary Trip register ($T_{UPPER}$)
0011 = Event Temperature Lower-Boundary Trip register ($T_{LOWER}$)
0100 = Critical Temperature Trip register ($T_{CRIT}$)
0101 = Temperature register ($T_A$)
0110 = Manufacturer ID register
0111 = Device ID/Revision register
1000 = Reserved
1001 = Resolution register
1XXX = Reserved (This device has additional registers that are reserved for test and calibration. If these registers are accessed, the device may not perform according to the specification.)


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**TABLE 5-1: BIT ASSIGNMENT SUMMARY FOR ALL TEMPERATURE SENSOR REGISTERS (SEE SECTION 5.3)**

| Register Pointer (Hex) | MSB/ LSB | Bit Assignment | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 0x00 | MSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LSB | SHDN Status | $t_{OUT}$ Range | 1 | Resolution | | Range | Accuracy | Event |
| 0x01 | MSB | 0 | 0 | 0 | 0 | 0 | Hysteresis | | SHDN |
| | LSB | Crt Loc | Win Loc | Int Clr | Evt Stat | Evt Cnt | Evt Sel | Evt Pol | Evt Mod |
| 0x02 | MSB | 0 | 0 | 0 | SIGN | $2^7$°C | $2^6$°C | $2^5$°C | $2^4$°C |
| | LSB | $2^3$°C | $2^2$°C | $2^1$°C | $2^0$°C | $2^{-1}$°C | $2^{-2}$°C | 0 | 0 |
| 0x03 | MSB | 0 | 0 | 0 | SIGN | $2^7$°C | $2^6$°C | $2^5$°C | $2^4$°C |
| | LSB | $2^3$°C | $2^2$°C | $2^1$°C | $2^0$°C | $2^{-1}$°C | $2^{-2}$°C | 0 | 0 |
| 0x04 | MSB | 0 | 0 | 0 | SIGN | $2^7$°C | $2^6$°C | $2^5$°C | $2^4$°C |
| | LSB | $2^3$°C | $2^2$°C | $2^1$°C | $2^0$°C | $2^{-1}$°C | $2^{-2}$°C | 0 | 0 |
| 0x05 | MSB | $T_A \geq T_{CRIT}$ | $T_A > T_{UPPER}$ | $T_A < T_{LOWER}$ | SIGN | $2^7$°C | $2^6$°C | $2^5$°C | $2^4$°C |
| | LSB | $2^3$°C | $2^2$°C | $2^1$°C | $2^0$°C | $2^{-1}$°C | $2^{-2}$°C | $2^{-3}$°C | $2^{-4}$°C |
| 0x06 | MSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LSB | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 0x07 | MSB | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | LSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0x08 | MSB | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | LSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0x09 | MSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LSB | 0 | 0 | 0 | 0 | 0 | 0 | Resolution | |

### 5.1.1 CAPABILITY REGISTER

This is a read-only register used to identify the temperature sensor capability. For example, the MCP9844 device is capable of providing temperature at 0.25°C resolution, measuring temperature below and above 0°C, providing ±1°C and ±2°C accuracy over the active and monitor temperature ranges (respectively) and providing user programmable temperature event boundary trip limits. Register 5-2 describes the Capability register. These functions are described in further detail in the following sections.

**REGISTER 5-2: CAPABILITY REGISTER (READ-ONLY) → ADDRESS '0000 0000'b**

| U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | — | — |
| bit 15 | | | | | | | bit 8 |

| R-1 | R-1 | R-1 | R-0 | R-1 | R-1 | R-1 | R-1 |
|---|---|---|---|---|---|---|---|
| SHDN Status | $t_{OUT}$ Range | — | Resolution | | Meas Range | Accuracy | Temp Alarm |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | | | |
|---|---|---|---|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15-8 **Unimplemented:** Read as '0'

bit 7 **Event output status during Shutdown (SHDN Status):**
- 0 = Event output remains in previous state. If the output asserts before shutdown command, it remains asserted during shutdown.
- 1 = Event output de-asserts during shutdown. After shutdown, it takes $t_{CONV}$ to re-assert the event output (power-up default)

bit 6 **$I^2C$ Bus time-out ($t_{OUT}$ Range):**
- 0 = Bus time-out range is 10 ms to 60 ms
- 1 = Bus time-out range is 25 ms to 35 ms (power-up default)

bit 5 **Unimplemented:** Read as '1'

bit 4-3 **Resolution:**
- 00 = 0.5°C
- 01 = 0.25°C (power-up default)
- 10 = 0.125°C
- 11 = 0.0625°C

These bits reflect the selected resolution (see **Section 5.2.4 "Temperature Resolution"**)

bit 2 **Temperature Measurement Range (Meas. Range):**
- 0 = $T_A = 0$ (decimal) for temperature below 0°C
- 1 = The part can measure temperature below 0°C (power-up default)


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**REGISTER 5-2: CAPABILITY REGISTER (READ-ONLY) → ADDRESS '0000 0000'b (CONTINUED)**

bit 1 **Accuracy:**

0 = Accuracy → ±2°C from +75°C to +95°C (Active Range) and ±3°C from +40°C to +125°C (Monitor Range)

1 = Accuracy → ±1°C from +75°C to +95°C (Active Range) and ±2°C from +40°C to +125°C (Monitor Range)

bit 0 **Temperature Alarm:**

0 = No defined function (This bit will never be cleared or set to '0')

1 = The part has temperature boundary trip limits ($T_{UPPER}/T_{LOWER}/T_{CRIT}$ registers) and a temperature event output (JC 42.4 required feature)

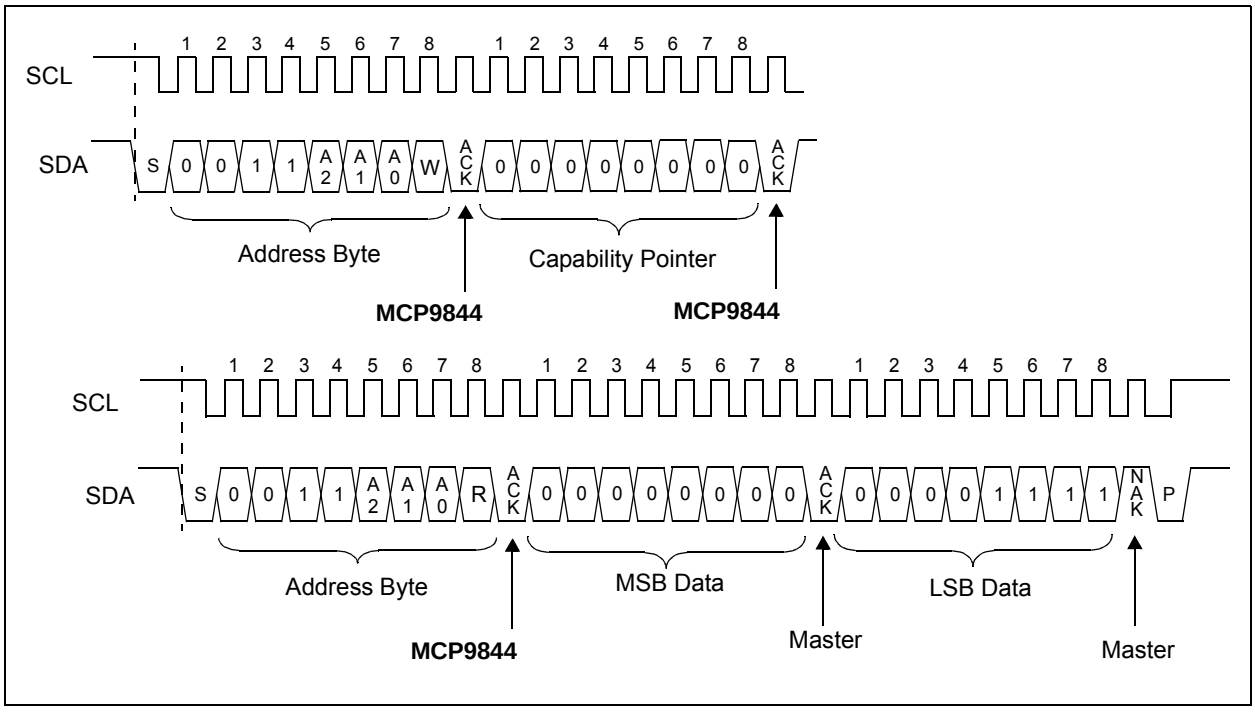


***FIGURE 5-2:*** *Timing Diagram for Reading the Capability Register (See **Section 4.0 "Serial Communication"**).*

### 5.1.2 SENSOR CONFIGURATION REGISTER (CONFIG)

The MCP9844 device has a 16-bit Configuration register (CONFIG) that allows the user to set various functions for a robust temperature monitoring system. Bits 10 through 0 are used to select the event output boundary hysteresis, device Shutdown or Low-Power mode, temperature boundary and critical temperature lock, and temperature event output enable/disable. In addition, the user can select the event output condition (output set for $T_{UPPER}$ and $T_{LOWER}$ temperature boundary or $T_{CRIT}$ only), read event output status and set event output polarity and mode (Comparator Output or Interrupt Output mode).

The temperature hysteresis bits 10 and 9 can be used to prevent output chatter when the ambient temperature gradually changes beyond the user specified temperature boundary (see **Section 5.2.2 "Temperature Hysteresis ($T_{HYST}$)"**). The Continuous Conversion or Shutdown mode is selected using bit 8. In Shutdown mode, the band gap temperature sensor circuit stops converting temperature and the Ambient Temperature register ($T_A$) holds the previous successfully converted temperature data (see **Section 5.2.1 "Shutdown Mode"**). Bits 7 and 6 are used to lock the user-specified boundaries $T_{UPPER}$, $T_{LOWER}$ and $T_{CRIT}$ to prevent an accidental rewrite. Bits 5 through 0 are used to configure the temperature Event output pin. All functions are described in Register 5-3 (see **Section 5.2.3 "Event Output Configuration"**).

**REGISTER 5-3: CONFIGURATION REGISTER (CONFIG) → ADDRESS '0000 0001'b**

| U-0 | U-0 | U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | $T_{HYST}$ | | SHDN |
| bit 15 | | | | | | | bit 8 |

| R/W-0 | R/W-0 | R/W-0 | R-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| Crit. Lock | Win. Lock | Int. Clear | Event Stat. | Event Cnt. | Event Sel. | Event Pol. | Event Mod. |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | | | |
|---|---|---|---|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15-11 **Unimplemented:** Read as '0'

bit 10-9 **$T_{UPPER}$ and $T_{LOWER}$ Limit Hysteresis ($T_{HYST}$):**
00 = 0°C (power-up default)
01 = 1.5°C
10 = 3.0°C
11 = 6.0°C

(Refer to **Section 5.2.3 "Event Output Configuration"**)

This bit can not be altered when either of the lock bits are set (bit 6 and bit 7).

This bit can be programmed in Shutdown mode.

bit 8 **Shutdown Mode (SHDN):**
0 = Continuous Conversion (power-up default)
1 = Shutdown (Low-Power mode)

In shutdown, all power-consuming activities are disabled, though all registers can be written to or read. Event output will de-assert.

This bit cannot be set '1' when either of the lock bits is set (bit 6 and bit 7). However, it can be cleared '0' for Continuous Conversion while locked (Refer to **Section 5.2.1 "Shutdown Mode"**).


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**REGISTER 5-3: CONFIGURATION REGISTER (CONFIG) → ADDRESS '0000 0001'b**

bit 7 **$T_{CRIT}$ Lock Bit (Crit. Lock):**

0 = Unlocked. $T_{CRIT}$ register can be written. (power-up default)
1 = Locked. $T_{CRIT}$ register can not be written

When enabled, this bit remains set '1' or locked until cleared by internal reset (**Section 5.3 "Summary of Power-on Default"**). This bit does not require a double-write.

This bit can be programmed in Shutdown mode.

bit 6 **$T_{UPPER}$ and $T_{LOWER}$ Window Lock Bit (Win. Lock):**

0 = Unlocked. $T_{UPPER}$ and $T_{LOWER}$ registers can be written. (power-up default)
1 = Locked. $T_{UPPER}$ and $T_{LOWER}$ registers can not be written

When enabled, this bit remains set '1' or locked until cleared by power-on Respell (**Section 5.3 "Summary of Power-on Default"**). This bit does not require a double-write.

This bit can be programmed in Shutdown mode.

bit 5 **Interrupt Clear (Int. Clear) Bit:**

0 = No effect (power-up default)
1 = Clear interrupt output. When read this bit returns '0'

This bit clears the Interrupt flag which de-asserts event output. In Shutdown mode, the event output is always de-asserted. Therefore, setting this bit in Shutdown mode clears the interrupt after the device returns to normal operation.

bit 4 **Event Output Status (Event Stat.) Bit:**

0 = Event output is not asserted by the device (power-up default)
1 = Event output is asserted as a comparator/Interrupt or critical temperature output

In Shutdown mode this bit will clear because event output is always de-asserted in shutdown mode.

bit 3 **Event Output Control (Event Cnt.) Bit:**

0 = Event output Disabled (power-up default)
1 = Event output Enabled

This bit can not be altered when either of the lock bits is set (bit 6 and bit 7).

This bit can be programmed in Shutdown mode, but event output will remain de-asserted.

bit 2 **Event Output Select (Event Sel.) Bit:**

0 = Event output for $T_{UPPER}$, $T_{LOWER}$ and $T_{CRIT}$ (power-up default)
1 = $T_A \geq T_{CRIT}$ only. ($T_{UPPER}$ and $T_{LOWER}$ temperature boundaries are disabled.)

When the Alarm Window Lock bit is set, this bit cannot be altered until unlocked (bit 6).

This bit can be programmed in Shutdown mode, but event output will remain de-asserted.

bit 1 **Event Output Polarity (Event Pol.) Bit:**

0 = Active low (power-up default. Pull-up resistor required)
1 = Active-high
This bit cannot be altered when either of the lock bits is set (bit 6 and bit 7).

This bit can be programmed in Shutdown mode, but event output will remain de-asserted, see **Section 5.2.3 "Event Output Configuration"**

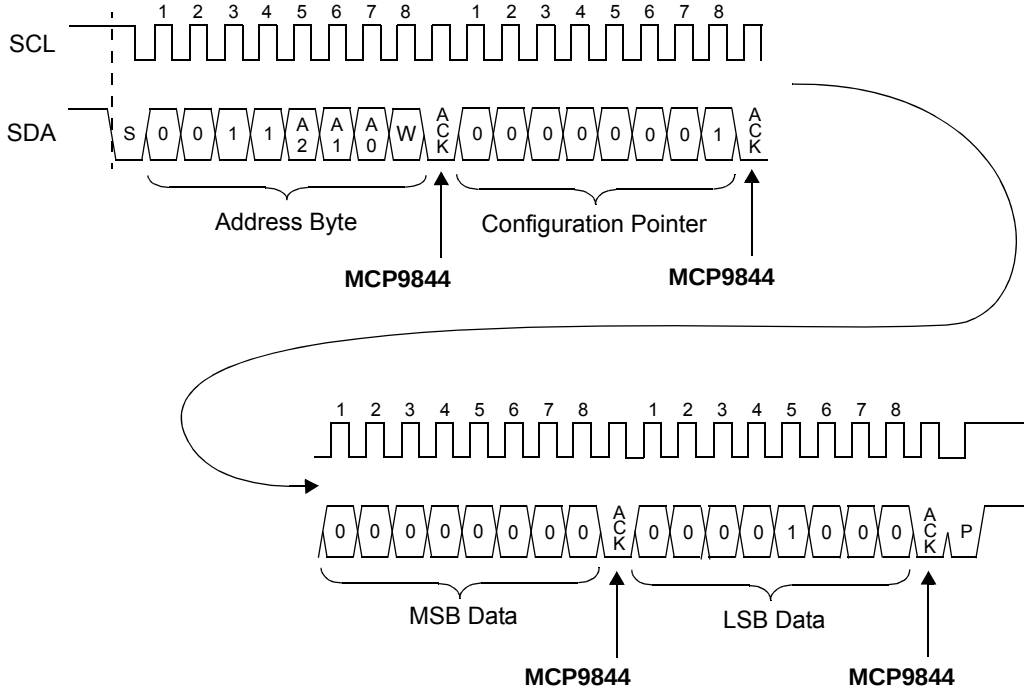
bit 0 **Event Output Mode (Event Mod.) Bit:**

0 = Comparator output (power-up default)
1 = Interrupt output

This bit cannot be altered when either of the lock bits is set (bit 6 and bit 7).

This bit can be programmed in Shutdown mode, but event output will remain de-asserted.

Writing to the CONFIG Register to Enable the Event Output pin <0000 0000 0000 1000>b.




**Note:** this is an example routine:

```
i2c_start();                    // send START command
i2c_write(AddressByte & 0xFE);  //WRITE Command
                                //also, make sure bit 0 is cleared '0'
i2c_write(0x01);                // Write CONFIG Register
i2c_write(0x00);                // Write data
i2c_write(0x08);                // Write data
i2c_stop();                     // send STOP command
```

***FIGURE 5-3:*** *Timing Diagram for Writing to the Configuration Register (See **Section 4.0 "Serial Communication"**.*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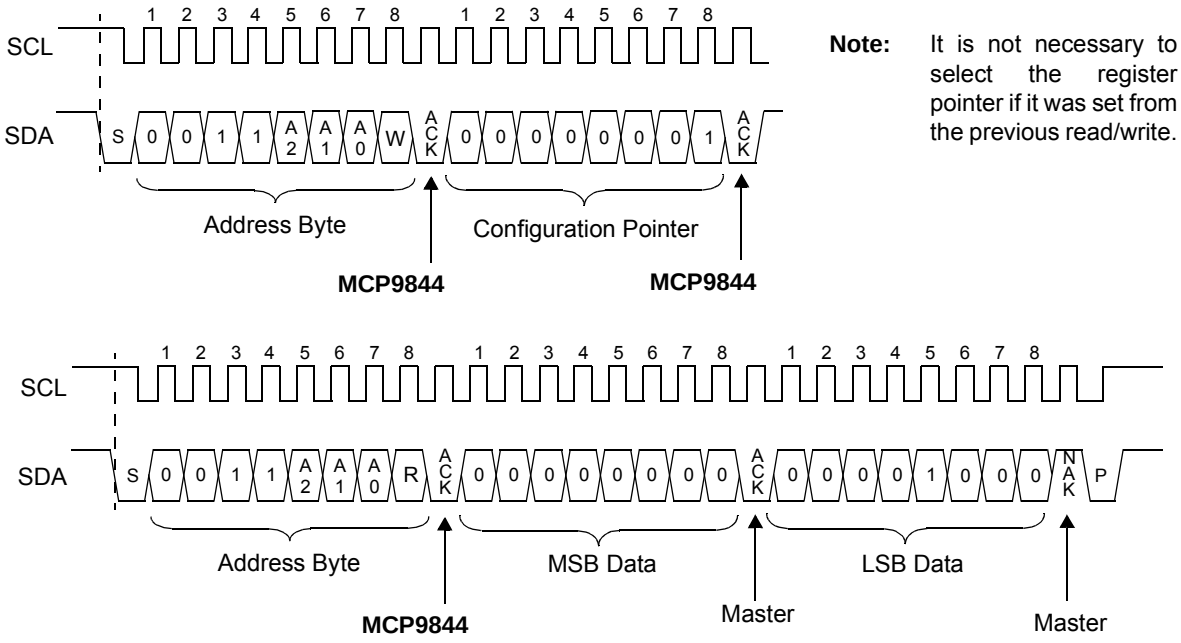
- Reading the CONFIG Register.




**Note:** It is not necessary to select the register pointer if it was set from the previous read/write.

**Note:** this is an example routine:

```
i2c_start();                          // send START command
i2c_write(AddressByte & 0xFE);        //WRITE Command
                                      //also, make sure bit 0 is cleared '0'
i2c_write(0x01);                      // Write CONFIG Register
i2c_start();                          // send Repeat START command
i2c_write(AddressByte | 0x01);        //READ Command
                                      //also, make sure bit 0 is set '1'
UpperByte = i2c_read(ACK);            // READ 8 bits
                                      //and Send ACK bit
LowerByte = i2c_read(NAK);            // READ 8 bits
                                      //and Send NAK bit
i2c_stop();                           // send STOP command
```

***FIGURE 5-4:*** *Timing Diagram for Reading from the Configuration Register (See* ***Section 4.0 "Serial Communication"****).*

### 5.1.3 UPPER/LOWER/CRITICAL TEMPERATURE LIMIT REGISTERS ($T_{UPPER}/T_{LOWER}/T_{CRIT}$)

The MCP9844 device has a 16-bit read/write Event Output Temperature Upper-Boundary Trip register ($T_{UPPER}$), a 16-bit Lower-Boundary Trip register ($T_{LOWER}$) and a 16-bit Critical Boundary Trip register ($T_{CRIT}$) that contains 11-bit data in two's complement format (0.25°C). This data represents the maximum and minimum temperature boundary or temperature window that can be used to monitor ambient temperature. If this feature is enabled (**Section 5.1.2 "Sensor Configuration Register (CONFIG)"**) and the ambient temperature exceeds the specified boundary or window, the MCP9844 asserts an event output. (Refer to **Section 5.2.3 "Event Output Configuration"**).

**REGISTER 5-4: UPPER/LOWER/CRITICAL TEMPERATURE LIMIT REGISTER ($T_{UPPER}/T_{LOWER}/T_{CRIT}$) → ADDRESS '0000 0010'b/'0000 0011'b/'0000 0100'b (Note 1)**

| U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | Sign | $2^7$°C | $2^6$°C | $2^5$°C | $2^4$°C |
| bit 15 | | | | | | | bit 8 |

| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | U-0 | U-0 |
|---|---|---|---|---|---|---|---|
| $2^3$°C | $2^2$°C | $2^1$°C | $2^0$°C | $2^{-1}$°C | $2^{-2}$°C | — | — |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | | | |
|---|---|---|---|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15-13 **Unimplemented:** Read as '0'

bit 12 **Sign:**
0 = $T_A \geq 0$°C
1 = $T_A < 0$°C

bit 11-2 **$T_{UPPER}/T_{LOWER}/T_{CRIT}$:**
Temperature boundary trip data in two's complement format.

bit 1-0 **Unimplemented:** Read as '0'

**Note 1:** This table shows two 16-bit registers for $T_{UPPER}$, $T_{LOWER}$ and $T_{CRIT}$ located at '0000 0010b', '0000 0011b' and '0000 0100b', respectively.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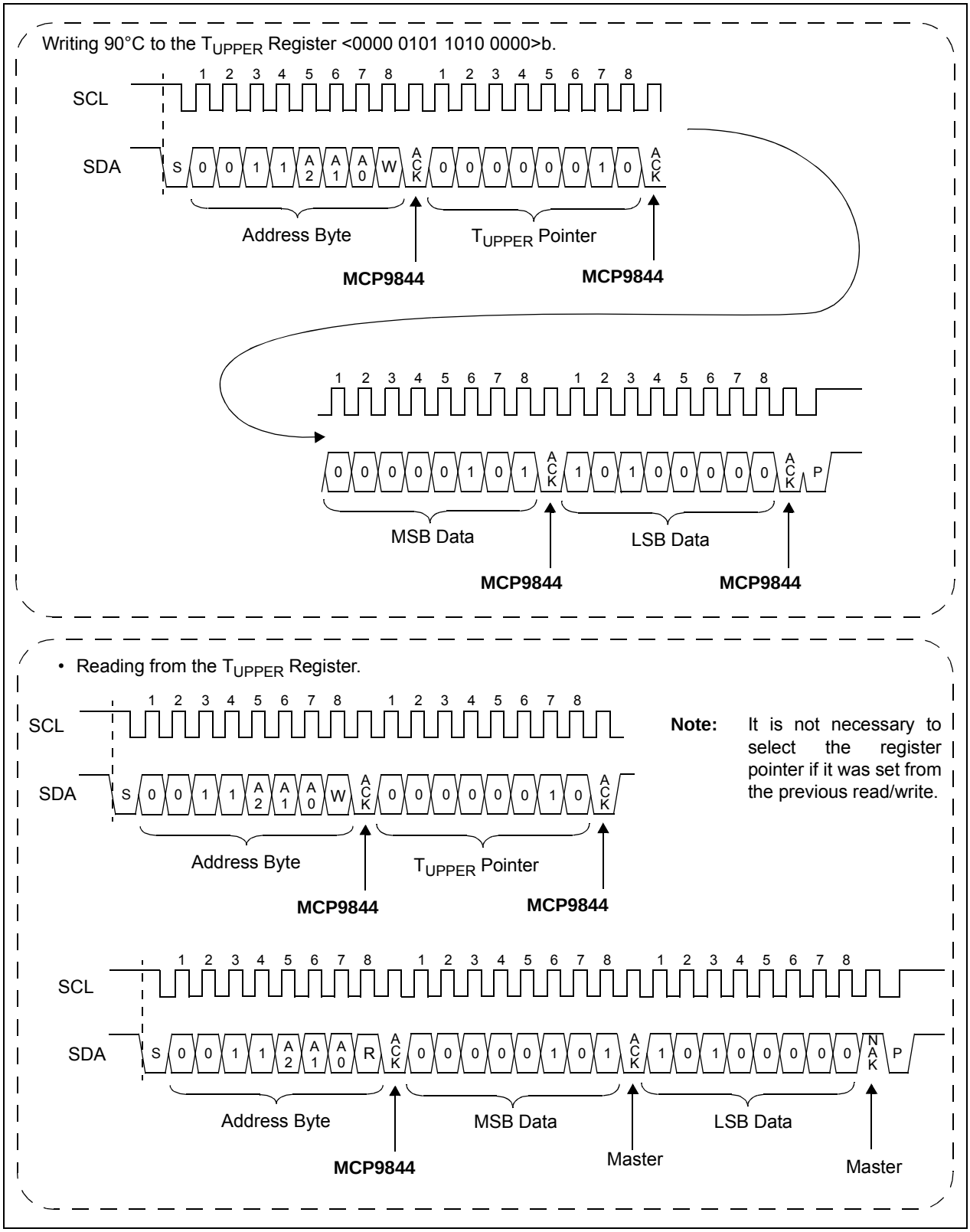


***FIGURE 5-5:*** *Timing Diagram for Writing and Reading from the $T_{UPPER}$ Register (See* ***Section 4.0 "Serial Communication"****).*

### 5.1.4 AMBIENT TEMPERATURE REGISTER ($T_A$)

The MCP9844 device uses a band gap temperature sensor circuit to output analog voltage proportional to absolute temperature. An internal ΔΣ ADC is used to convert the analog voltage to a digital word. The converter resolution is set to 0.25°C + sign (11-bit data). The digital word is loaded to a 16-bit read-only Ambient Temperature register ($T_A$) that contains 11-bit temperature data in two's complement format.

The $T_A$ register bits (bits 12 through 0) are double-buffered. Therefore, the user can access the register while, in the background, the MCP9844 performs an analog-to-digital conversion. The temperature data from the ΔΣ ADC is loaded in parallel to the $T_A$ register at $t_{CONV}$ refresh rate.

In addition, the $T_A$ register uses three bits (bits 15, 14 and 13) to reflect the Event pin state. This allows the user to identify the cause of the event output trigger (see **Section 5.2.3 "Event Output Configuration"**); bit 15 is set to '1' if $T_A$ is greater than or equal to $T_{CRIT}$, bit 14 is set to '1' if $T_A$ is greater than $T_{UPPER}$ and bit 13 is set to '1' if $T_A$ is less than $T_{LOWER}$.

The $T_A$ register bit assignment and boundary conditions are described in Register 5-5.

**REGISTER 5-5: AMBIENT TEMPERATURE REGISTER ($T_A$) → ADDRESS '0000 0101'b (Note 1)**

| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 |
|---|---|---|---|---|---|---|---|
| $T_A$ vs. $T_{CRIT}$ | $T_A$ vs. $T_{UPPER}$ | $T_A$ vs. $T_{LOWER}$ | SIGN | $2^7$ °C | $2^6$ °C | $2^5$ °C | $2^4$ °C |
| bit 15 | | | | | | | bit 8 |

| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 |
|---|---|---|---|---|---|---|---|
| $2^3$ °C | $2^2$ °C | $2^1$ °C | $2^0$ °C | $2^{-1}$ °C | $2^{-2}$ °C | $2^{-3}$ °C | $2^{-4}$ °C |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | | | |
|---|---|---|---|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15 **$T_A$ vs. $T_{CRIT}$ (1) Bit:**
- 0 = $T_A < T_{CRIT}$
- 1 = $T_A \geq T_{CRIT}$

bit 14 **$T_A$ vs. $T_{UPPER}$ (1) Bit:**
- 0 = $T_A \leq T_{UPPER}$
- 1 = $T_A > T_{UPPER}$

bit 13 **$T_A$ vs. $T_{LOWER}$ (1) Bit:**
- 0 = $T_A \geq T_{LOWER}$
- 1 = $T_A < T_{LOWER}$

bit 12 **SIGN Bit:**
- 0 = $T_A \geq 0$°C
- 1 = $T_A < 0$°C

bit 11-0 **Ambient Temperature ($T_A$) Bits: (Note 2)**

12-bit Ambient Temperature data in two's complement format.

**Note 1:** Bits 15, 14 and 13 are not affected by the status of the event output configuration (bits 5 to 0 of CONFIG) (Register 5-3).

**2:** Bits 2, 1, and 0 may remain clear '0' depending on the status of the resolution register. The power-up default is 0.25°C/bit, bits 1 and 0 remain clear '0'.


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#### 5.1.4.1 $T_A$ bits to Temperature Conversion

To convert the $T_A$ bits to decimal temperature, the upper three boundary bits 15, 14 and 13) must be masked out. Then determine the sign bit (bit 12) to check positive or negative temperature, shift the bits accordingly and combine the upper and lower bytes of the 16-bit register. The upper byte contains data for temperatures greater than 32°C while the lower byte contains data for temperature less than 32°C, including fractional data. When combining the upper and lower bytes, the upper byte must be right-shifted by 4 bits (or multiply by $2^4$), and the lower byte must be left-shifted by 4 bits (or multiply by $2^{-4}$). Adding the results of the shifted values provides the temperature data in decimal format, see Equation 5-1.

The temperature bits are in two's compliment format; therefore, positive temperature data and negative temperature data are computed differently. Equation 5-1 shows the temperature computation. The example instruction code outlined in Figure 5-6 shows the communication flow. Additionally, refer to Figure 5-7 for the timing diagram.

**EQUATION 5-1: BYTES TO TEMPERATURE CONVERSION**

Temperature ≥ 0°C

$$T_A = (UpperByte \times 2^4 + LowerByte \times 2^{-4})$$

Temperature < 0°C

$$T_A = 256 - (UpperByte \times 2^4 + LowerByte \times 2^{-4})$$

Where:

$T_A$ = Ambient Temperature (°C)
UpperByte = $T_A$ bit 15 to bit 8
LowerByte = $T_A$ bit 7 to bit 0

This example routine assumes the variables and I²C communication subroutines are predefined:

```
i2c_start();                              // send START command
i2c_write(AddressByte & 0xFE);            //WRITE Command
                                          //also, make sure bit 0 is cleared '0'
i2c_write(0x05);                          // Write TA Register Address
i2c_start();                              //Repeat START
i2c_write(AddressByte | 0x01);            // READ Command
                                          //also, make sure bit 0 is Set '1'
UpperByte = i2c_read(ACK);                // READ 8 bits
                                          //and Send ACK bit
LowerByte = i2c_read(NAK);                // READ 8 bits
                                          //and Send NAK bit
i2c_stop();                               // send STOP command
//Convert the temperature data
//First Check flag bits
if ((UpperByte & 0x80) == 0x80){          //TA ≥ TCRIT
}
if ((UpperByte & 0x40) == 0x40){          //TA > TUPPER
}
if ((UpperByte & 0x20) == 0x20){          //TA < TLOWER
}
UpperByte = UpperByte & 0x1F;             //Clear flag bits
if ((UpperByte & 0x10) == 0x10){          //TA < 0°C
    UpperByte = UpperByte & 0x0F;         //Clear SIGN
    Temperature = 256 - (UpperByte x 16 + LowerByte / 16);
}else                                     //TA ≥ 0°C
    Temperature = (UpperByte x 16 + LowerByte / 16);
                                          //Temperature = Ambient Temperature (°C)
```

***FIGURE 5-6:*** *Example Instruction Code.*

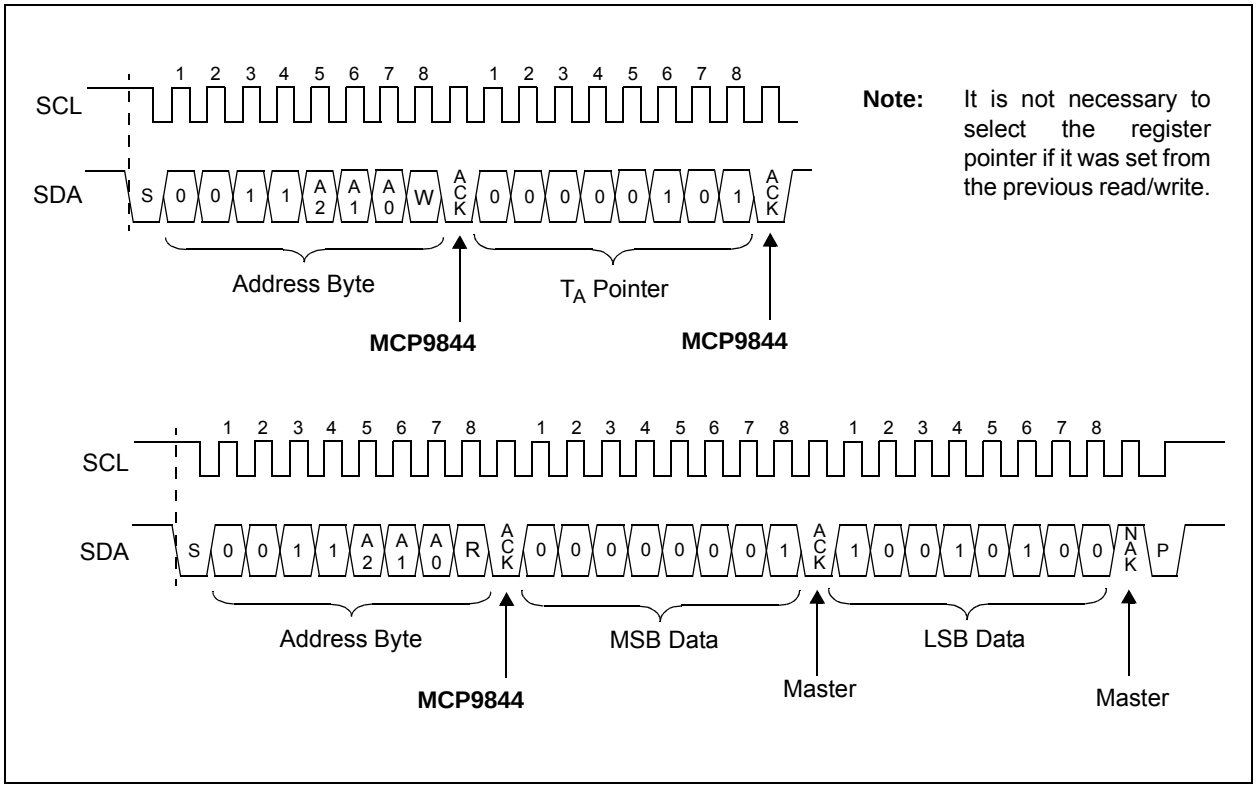


***FIGURE 5-7:*** *Timing Diagram for Reading +25.25°C Temperature from the $T_A$ Register (See* ***Section 4.0 "Serial Communication"****).*


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### 5.1.5 MANUFACTURER ID REGISTER

This register is used to identify the manufacturer of the device in order to perform manufacturer specific operations. The Manufacturer ID for the MCP9844 is 0x0054 (hexadecimal).

**REGISTER 5-6: MANUFACTURER ID REGISTER (READ-ONLY) → ADDRESS '0000 0110'b**

| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 |
|---|---|---|---|---|---|---|---|
| Manufacturer ID | | | | | | | |
| bit 15 | | | | | | | bit 8 |

| R-0 | R-1 | R-0 | R-1 | R-0 | R-1 | R-0 | R-0 |
|---|---|---|---|---|---|---|---|
| Manufacturer ID | | | | | | | |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | | | |
|---|---|---|---|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15-0 **Device Manufacturer Identification Number**

.

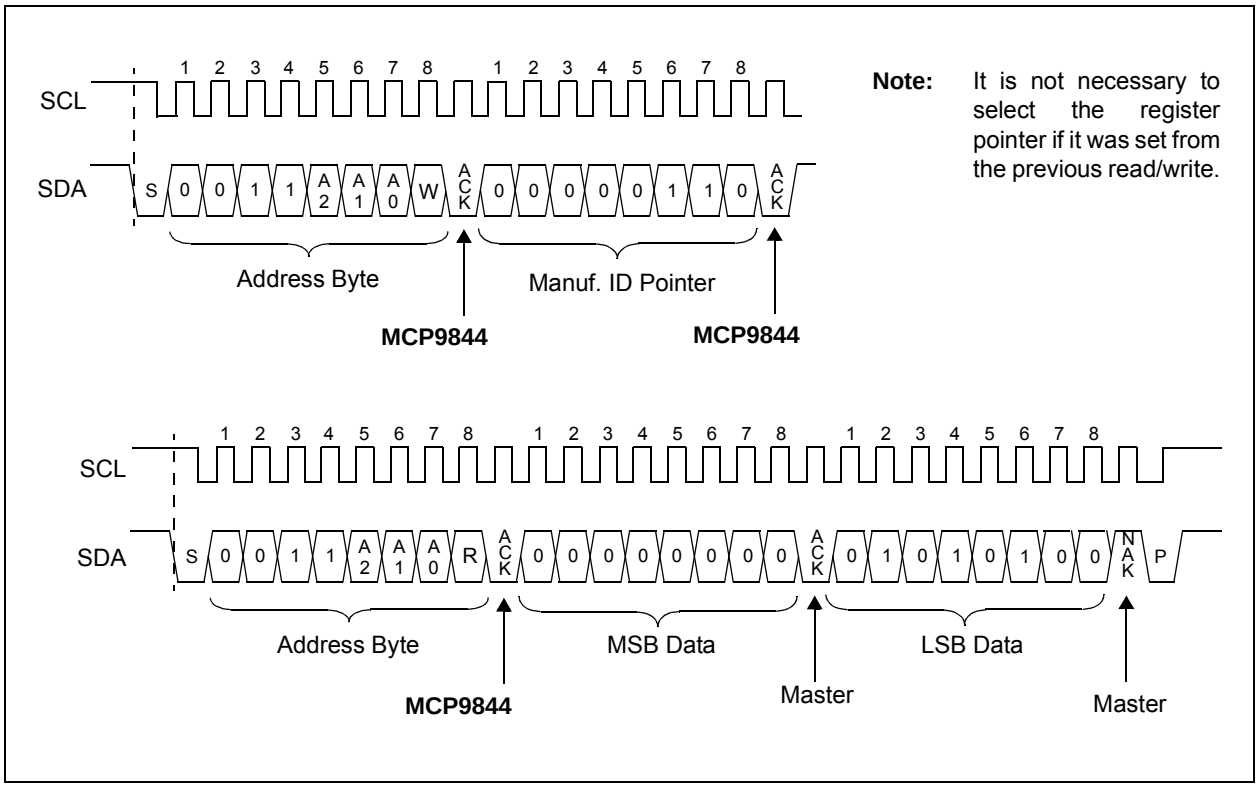


***FIGURE 5-8:*** *Timing Diagram for Reading the Manufacturer ID Register (See **Section 4.0 "Serial Communication"**).*

### 5.1.6 DEVICE ID AND REVISION REGISTER

The Device ID and Revision register located at address pointer 0x08 is used to identify Microchip devices. The upper byte of these registers is used to specify the device identification and the lower byte is used to specify device silicon revision. The device ID for the MCP9844 is 0x06 (hex) and the silicon revision is 0x00.

The revision (Lower Byte) begins with 0x00 (hex) for the first release, with the number being incremented as revised versions are released.

**REGISTER 5-7: TSE2004AV DEVICE ID AND DEVICE REVISION (READ-ONLY) → ADDRESS '0000 0111'b AND '0000 1000'b**

| R-0 | R-0 | R-0 | R-0 | R-0 | R-1 | R-1 | R-0 |
|---|---|---|---|---|---|---|---|
| Device ID | | | | | | | |
| bit 15 | | | | | | | bit 8 |

| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-1 |
|---|---|---|---|---|---|---|---|
| Device Revision | | | | | | | |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | | | |
|---|---|---|---|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15-8 **Device ID:** Bit 15 to bit 8 are used for device ID

bit 7-0 **Device Revision:** Bit 7 to bit 0 are used for device revision


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### 5.1.7 RESOLUTION REGISTER

This register allows the user to change the sensor resolution (see **Section 5.2.4 "Temperature Resolution"**). The POR default resolution is 0.25°C. The selected resolution is also reflected in the Capability register (see Register 5-2).

**Note:** In order to prevent accidentally writing the resolution register to a higher resolution and exceeding the maximum temperature conversion time of $t_{CONV}$ = 125 ms, a Shutdown command (using the CONFIG register) is required to change the resolution register. The device must be in Shutdown mode to change the resolution.

**REGISTER 5-8: RESOLUTION REGISTER → '0000 1001'b**

| R/W-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 |
|---|---|---|---|---|---|---|---|
| — | | | | | | | |
| bit 15 | | | | | | | bit 8 |

| U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | R/W-0 | R/W-1 |
|---|---|---|---|---|---|---|---|
| Resolution | | | | | | | |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | | | |
|---|---|---|---|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15 **Unimplemented:** Read as '0'

bit 14-2 **Unimplemented:** Read as '0'

bit 1-0 **Resolution:**

00 = LSb = 0.5°C ($t_{CONV}$ = 30 ms typical)
01 = LSb = 0.25°C (power up default, $t_{CONV}$ = 65 ms typical)
10 = LSb = 0.125°C ($t_{CONV}$ = 130 ms typical)
11 = LSb = 0.0625°C ($t_{CONV}$ = 260 ms typical)

## 5.2 SENSOR FEATURE DESCRIPTION

### 5.2.1 SHUTDOWN MODE

Shutdown mode disables all power-consuming activities (including temperature sampling operations) while leaving the serial interface active. This mode is selected by setting bit 8 of CONFIG to '1'. In this mode, the device consumes $I_{SHDN}$. It remains in this mode until bit 8 is cleared '0' to enable Continuous Conversion mode, or until power is recycled.

The Shutdown bit (bit 8) cannot be set to '1' while bits 6 and 7 of CONFIG (Lock bits) are set to '1'. However, it can be cleared '0' or returned to Continuous Conversion while locked.

In Shutdown mode, all registers can be read or written. However, the serial bus activity increases the shutdown current.

If the device is shutdown while the Event pin is asserted, then the event output will be de-asserted during shutdown. It will remain de-asserted until the device is enabled for normal operation. Once the device is enabled, it takes $t_{CONV}$ before the device reasserts the event output.

### 5.2.2 TEMPERATURE HYSTERESIS ($T_{HYST}$)

A hysteresis of 0°C, 1.5°C, 3°C or 6°C can be selected for the $T_{UPPER}$, $T_{LOWER}$ and $T_{CRIT}$ temperate boundaries using bits 10 and 9 of CONFIG. The hysteresis applies for decreasing temperature only (hot to cold), or as temperature drifts below the specified limit.

The hysteresis bits can not be changed if either of the lock bits, bits 6 and 7 of CONFIG, are set to '1'.

The $T_{UPPER}$, $T_{LOWER}$ and $T_{CRIT}$ boundary conditions are described graphically in Figure 5-9.

### 5.2.3 EVENT OUTPUT CONFIGURATION

The event output can be enabled using bit 3 of CONFIG (Event Output Control bit) and can be configured as either a comparator output or as Interrupt Output mode using bit 0 of CONFIG (Event mode). The polarity can also be specified as an active-high or active-low using bit 1 of CONFIG (event polarity). The event output requires a pull-up resistor to function.

These configurations are designed to serve processors with Low-to-High or High-to-Low edge triggered inputs. With active-high configuration, when the event output de-asserts, power will be dissipated across the pull-up resistor.

When the ambient temperature increases above the critical temperature limit, the event output is forced to a comparator output (regardless of bit 0 of CONFIG). When the temperature drifts below the critical temperature limit minus hysteresis, the event output automatically returns to the state specified by bit 0 of CONFIG.

The status of the event output can be read using bit 4 of CONFIG (Event status). This bit can not be set to '1' in Shutdown mode.

Bit 7 and 6 of the CONFIG register can be used to lock the $T_{UPPER}$, $T_{LOWER}$ and $T_{CRIT}$ registers. The bits prevent false triggers at the event output due to an accidental rewrite to these registers.

The event output can also be used as a critical temperature output using bit 2 of CONFIG (critical output only). When this feature is selected, the event output becomes a comparator output. In this mode, the interrupt output configuration (bit 0 of CONFIG) is ignored.


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#### 5.2.3.1 Comparator Mode

Comparator mode is selected using bit 0 of CONFIG. In this mode, the event output is asserted as active-high or active-low using bit 1 of CONFIG. Figure 5-9 shows the conditions that toggle the event output.

If the device enters Shutdown mode with asserted event output, the output will de-assert. It will remain de-asserted until the device enters Continuous Conversion mode and after the first temperature conversion is completed, $t_{CONV}$. After the initial temperature conversion, $T_A$ must satisfy the $T_{UPPER}$ or $T_{LOWER}$ boundary conditions in order for event output to be asserted.

Comparator mode is useful for thermostat type applications, such as turning on a cooling fan or triggering a system shutdown when the temperature exceeds a safe operating range.

#### 5.2.3.2 Interrupt Mode

In Interrupt mode, the event output is asserted as active-high or active-low (depending on the polarity configuration) when $T_A$ drifts above or below $T_{UPPER}$ and $T_{LOWER}$ limits. The output is de-asserted by setting bit 5 (Interrupt Clear) of CONFIG. If the device enters Shutdown mode with asserted event output, the output will de-assert. It will remain de-asserted until the device enters Continuous Conversion mode and after the first temperature conversion is completed, $t_{CONV}$. If the interrupt clear bit (Bit 5) is never set, then the event output will re-assert after the first temperature conversion.

In addition, if $T_A >= T_{CRIT}$, the event output is forced as Comparator mode and asserts until $T_A < T_{CRIT} - T_{HYST}$. While the event output is asserted, the user must send a Clear Interrupt command (bit 5 of CONFIG) for the event output to de-assert when the temperature drops below the critical limit, $T_A < T_{CRIT} - T_{HYST}$. Otherwise, the event output remains asserted (see Figure 5-9 for a graphical description). Switching from Interrupt mode to Comparator mode also de-asserts event output.

This mode is designed for interrupt driven microcontroller based systems. The microcontroller receiving the interrupt will have to acknowledge the interrupt by setting bit 5 of the CONFIG register from the MCP9844.

### 5.2.4 TEMPERATURE RESOLUTION

The MCP9844 device is capable of providing temperature data with 0.5°C to 0.0625°C resolution. The Resolution can selected using the Resolution register (Register 5-8) which is located in address '00001001'b. This address location is not specified in JEDEC Standard JC42.4. However, it provides additional flexibility while being functionally compatible with JC42.4 and provides a 0.25°C resolution at 125 ms (max.). In order to prevent accidentally changing the resolution and exceeding the 125 ms conversion time, the device must be in Shutdown mode to change this register. The selected resolution can be read by the user using bit 4 and bit 3 of the Capability register (Register 5-2). A 0.25°C resolution is set as POR default by the factory.

**TABLE 5-2: TEMPERATURE CONVERSION TIME**

| Resolution | $t_{CONV}$ (ms) | Samples/sec (typical) |
|---|---|---|
| 0.5°C | 30 | 33 |
| 0.25°C (Power-up default) | 65 | 15 |
| 0.125°C | 130 | 8 |
| 0.0625°C | 260 | 4 |

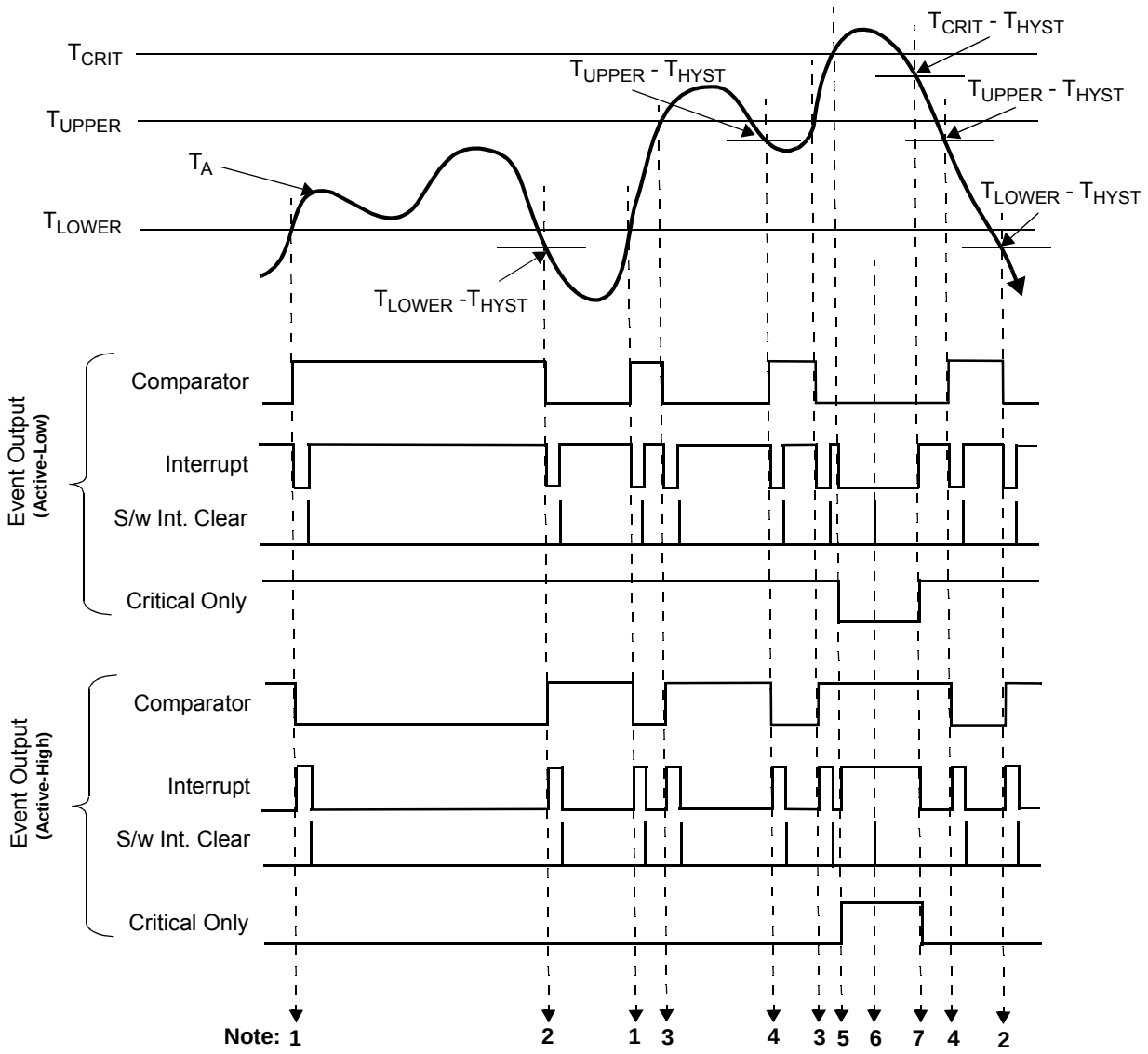


**TABLE 5-9: TEMPERATURE EVENT OUTPUT CONDITIONS**

| Note | Output Boundary Conditions | Comparator | Interrupt | Critical | $T_A$ Bits | | |
|---|---|---|---|---|---|---|---|
| | | Output State (Active Low/High) | | | 15 | 14 | 13 |
| 1 | $T_A \geq T_{LOWER}$ | High/Low | Low/High | High/Low | 0 | 0 | 0 |
| 2 | $T_A < T_{LOWER} - T_{HYST}$ | Low/High | Low/High | High/Low | 0 | 0 | 1 |
| 3 | $T_A > T_{UPPER}$ | Low/High | Low/High | High/Low | 0 | 1 | 0 |
| 4 | $T_A \leq T_{UPPER} - T_{HYST}$ | High/Low | Low/High | High/Low | 0 | 0 | 0 |
| 5 | $T_A \geq T_{CRIT}$ | Low/High | Low/High | Low/High | 1 | 1 | 0 |
| 6 | When $T_A \geq T_{CRIT}$, the event output is forced to Comparator Mode and bits 0 of CONFIG (Event Output mode) is ignored until $T_A < T_{CRIT} - T_{HYST}$. In Interrupt Mode, if Interrupt is not cleared (bits 5 of CONFIG) as shown in the diagram at **Note 6**, then the event will remain asserted at **Note 7** until the Interrupt is cleared by the controller. | | | | | | |
| 7 | $T_A < T_{CRIT} - T_{HYST}$ | Low/High | High/Low | High/Low | 0 | 1 | 0 |

***FIGURE 5-9:*** *Event Output Condition.*


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## 5.3 Summary of Power-on Default

The MCP9844 has an internal Power-on Reset (POR) circuit. If the power supply voltage $V_{DD}$ glitches down to the $V_{POR_TS}$ and $V_{POR_EE}$ thresholds, the device resets the registers to the power-on default settings.

Table 5-3 shows the power-on default summary for the temperature sensor.

**TABLE 5-3: MCP9844 TEMPERATURE SENSOR POWER-ON RESET DEFAULTS**

| Registers | | Default Register Data (Hexadecimal) | Power-up Default Register Description |
|---|---|---|---|
| Address (Hexadecimal) | Register Name | | |
| 0x00 | Capability | 0x00EF | Event output de-asserts in shutdown<br>$I^2C$ time out 25 ms to 35 ms.<br>Accepts $V_{HV}$ at A0 Pin<br>0.25°C Measurement Resolution<br>Measures temperature below 0°C<br>±1°C accuracy over active range<br>Temperature event output |
| 0x01 | CONFIG | 0x0000 | Comparator mode<br>Active-Low output<br>Event and critical output<br>Output disabled<br>Event not asserted<br>Interrupt cleared<br>Event limits unlocked<br>Critical limit unlocked<br>Continuous conversion<br>0°C Hysteresis |
| 0x02 | $T_{UPPER}$ | 0x0000 | 0°C |
| 0x03 | $T_{LOWER}$ | 0x0000 | 0°C |
| 0x04 | $T_{CRIT}$ | 0x0000 | 0°C |
| 0x05 | $T_A$ | 0x0000 | 0°C |
| 0x06 | Manufacturer ID | 0x0054 | — |
| 0x07 | Reserved | 0x0601 | — |
| 0x08 | Microchip Device ID/ Device Revision | 0x0601 | — |
| 0x09 | Resolution | 0x0001 | Most Significant bit is set by default<br>0.25°C Measurement Resolution |

**NOTES:**


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# 6.0 APPLICATIONS INFORMATION

## 6.1 Layout Considerations

The MCP9844 device does not require any additional components besides the master controller in order to measure temperature. However, it is recommended that a decoupling capacitor of 0.1 µF to 1 µF be used between the $V_{DD}$ and GND pins. A high-frequency ceramic capacitor is recommended. It is necessary for the capacitor to be located as close as possible to the power and ground pins of the device in order to provide effective noise protection.

In addition, good PCB layout is key for better thermal conduction from the PCB temperature to the sensor die. For good temperature sensitivity, add a ground layer under the device pins as shown in Figure 6-1.

## 6.2 Thermal Considerations

A potential for self-heating errors can exist if the MCP9844 SDA, SCLK and event lines are heavily loaded with pull-ups (high current). Typically, the self-heating error is negligible because of the relatively small current consumption of the MCP9844. A temperature accuracy error of approximately 0.5°C could result from self-heating if the communication pins sink/source the maximum current specified.

For example, if the event output is loaded to maximum $I_{OL}$, Equation 6-1 can be used to determine the effect of self-heating.

**EQUATION 6-1: EFFECT OF SELF-HEATING**

$$T_\Delta = \theta_{JA}(V_{DD} \bullet I_{DD} + V_{OL_Event} \bullet I_{OL_Event} + V_{OL_SDA} \bullet I_{OL_SDA})$$

Where:

$T_\Delta$ = $T_J$ - $T_A$

$T_J$ = Junction Temperature

$T_A$ = Ambient Temperature

$\theta_{JA}$ = Package Thermal Resistance

$V_{OL_Event, SDA}$ = Event and SDA Output $V_{OL}$ (0.4 $V_{max}$)

$I_{OL_Event, SDA}$ = Event and SDA Output $I_{OL}$ (3 $mA_{max}$ and 20 $mA_{max}$, respectively)

At room temperature ($T_A$ = +25°C) with maximum $I_{DD}$ = 500 µA and $V_{DD}$ = 3.6V, the self-heating due to power dissipation $T_\Delta$ is 0.58°C for the TDFN-8 package.

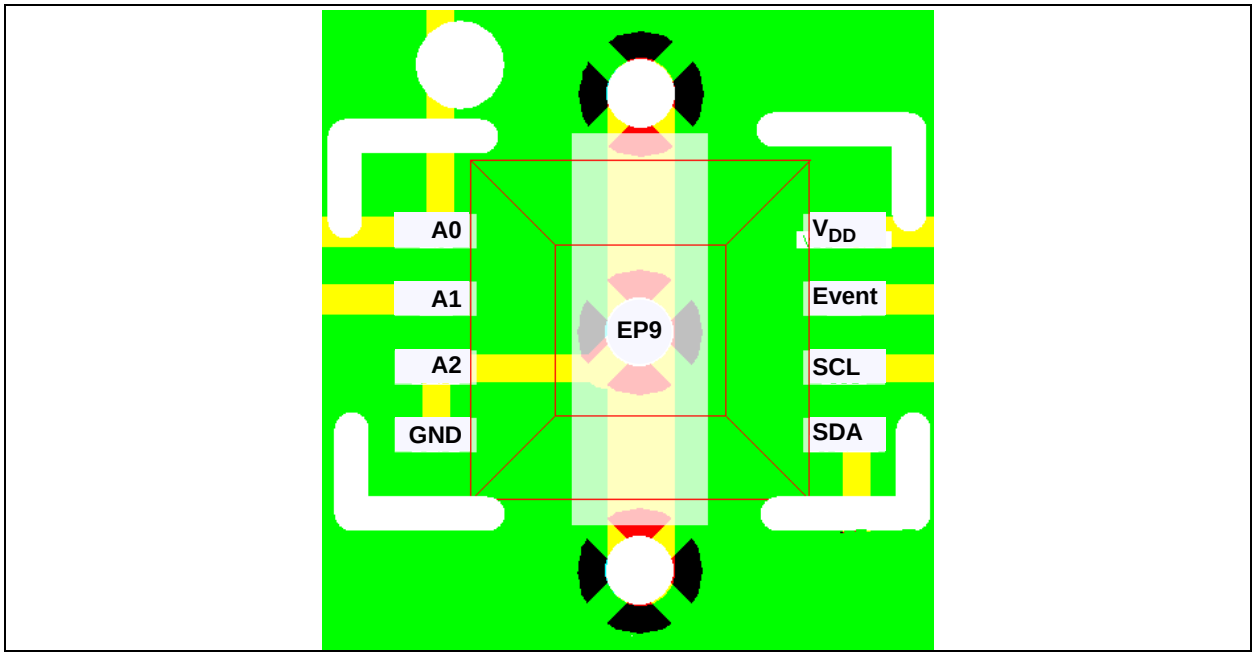


***FIGURE 6-1:*** *TDFN Package Layout.*

**NOTES:**


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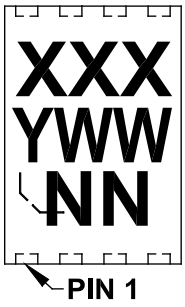
## 7.0 PACKAGING INFORMATION

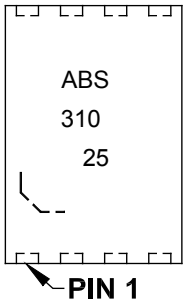
### 7.1 Package Marking Information

8-Lead TDFN (2x3) **(MCP9844)**




| Part Number | Code |
|---|---|
| MCP9844T-BE/MNY | ABS |

Example:

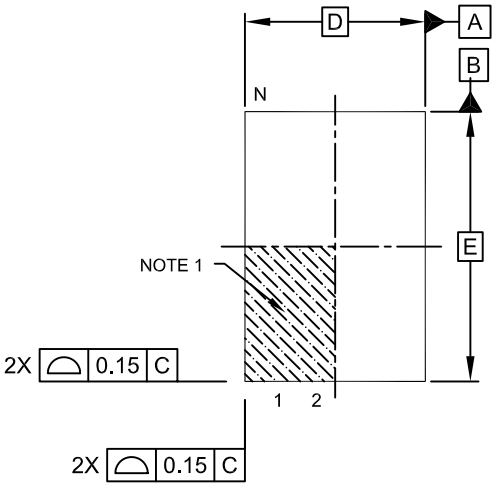



| | | |
|---|---|---|
| **Legend:** | XX...X | Customer-specific information |
| | Y | Year code (last digit of calendar year) |
| | YY | Year code (last 2 digits of calendar year) |
| | WW | Week code (week of January 1 is week ‘01’) |
| | NNN | Alphanumeric traceability code |
| | (e3) | Pb-free JEDEC designator for Matte Tin (Sn) |
| | * | This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package. |

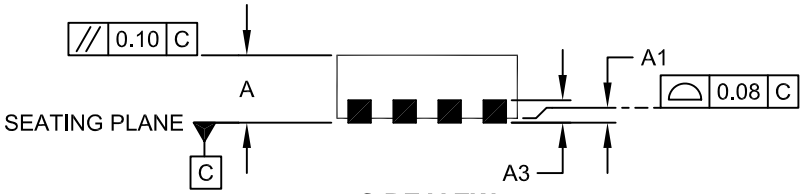
**Note**: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

## 8-Lead Plastic Dual Flat, No Lead Package (MN) – 2x3x0.75mm Body [TDFN]

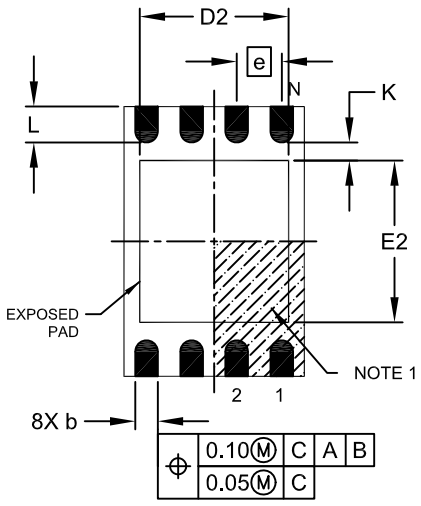
**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging




**TOP VIEW**




**SIDE VIEW**




**BOTTOM VIEW**

Microchip Technology Drawing No. C04-129C Sheet 1 of 2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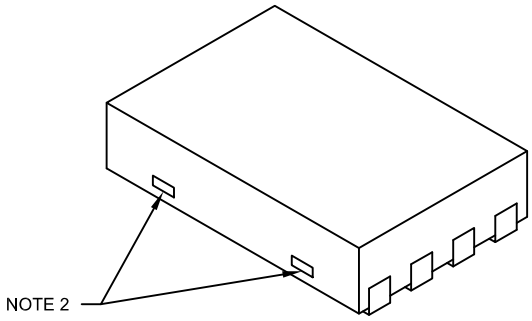
## 8-Lead Plastic Dual Flat, No Lead Package (MN) – 2x3x0.75mm Body [TDFN]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging




| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Number of Pins | N | | 8 | |
| Pitch | e | | 0.50 BSC | |
| Overall Height | A | 0.70 | 0.75 | 0.80 |
| Standoff | A1 | 0.00 | 0.02 | 0.05 |
| Contact Thickness | A3 | | 0.20 REF | |
| Overall Length | D | | 2.00 BSC | |
| Overall Width | E | | 3.00 BSC | |
| Exposed Pad Length | D2 | 1.20 | - | 1.60 |
| Exposed Pad Width | E2 | 1.20 | - | 1.60 |
| Contact Width | b | 0.20 | 0.25 | 0.30 |
| Contact Length | L | 0.25 | 0.30 | 0.45 |
| Contact-to-Exposed Pad | K | 0.20 | - | - |

**Notes:**

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package may have one or more exposed tie bars at ends.
3. Package is saw singulated
4. Dimensioning and tolerancing per ASME Y14.5M

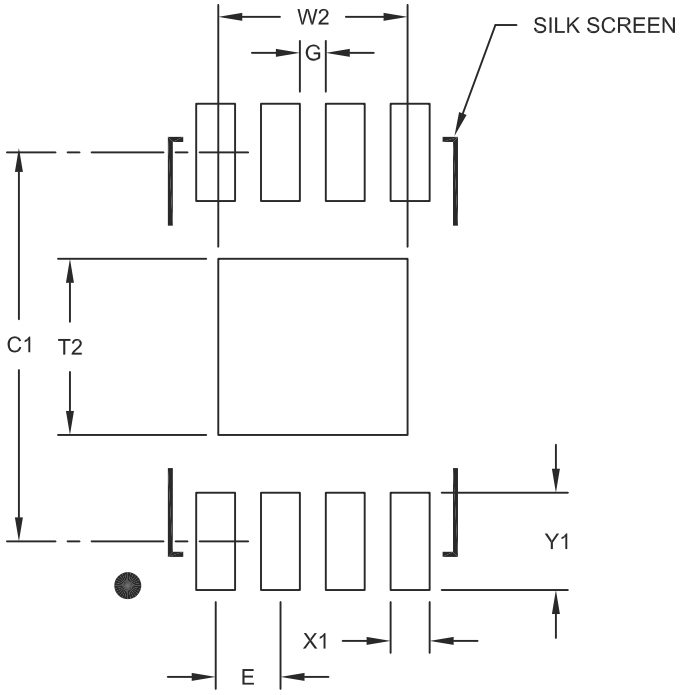
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing No. C04-129C Sheet 2 of 2

### 8-Lead Plastic Dual Flat, No Lead Package (MN) – 2x3x0.75 mm Body [TDFN]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging




RECOMMENDED LAND PATTERN

| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Contact Pitch | E | | 0.50 BSC | |
| Optional Center Pad Width | W2 | | | 1.46 |
| Optional Center Pad Length | T2 | | | 1.36 |
| Contact Pad Spacing | C1 | | 3.00 | |
| Contact Pad Width (X8) | X1 | | | 0.30 |
| Contact Pad Length (X8) | Y1 | | | 0.75 |
| Distance Between Pads | G | 0.20 | | |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2129A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# APPENDIX A: REVISION HISTORY

## Revision A (March 2012)

- Original Release of this Document.

**NOTES:**


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## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

| PART NO. | -X | /XX |
|---|---|---|
| Device | Temperature Range | Package |

| | | |
|---|---|---|
| **Device:** | MCP9844T: | Single Op Amp (Tape and Reel) |
| **Temperature Range:** | E = | -40°C to +125°C (Extended) |
| **Package:** | MNY* = | Plastic Dual Flat, No Lead, (2x3 TDFN), 8-lead (TDFN) |

* Y = Nickel palladium gold manufacturing designator. Only available on the TDFN package.

**Examples:**

a) MCP9844T-BE/MNY: Tape and Reel, Extended Temp., 8LD 2x3 TDFN pkg.

**NOTES:**


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**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
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- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
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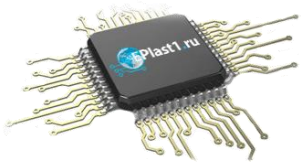
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.

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